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SECTION 205 RECONNAISSANCE REPORT

Chattooga River
TRION, GEORGIA
CHATTOOGA COUNTY

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US Army Corps
of Engineers
Mobile District

ACKNOWLEDGEMENT

Primary study team personnel who are familiar with the technical aspects of Preconstruction Engineering and Design are listed below:

PROJECT MANAGER:	Mathew M. Laws, III
STUDY MANAGER:	Walter W. Burdin
ENGINEERING MANAGER:	William G. Greenlee
CHANNEL DESIGN:	Lyndal K. (Pete) Robinson
ISLAND DESIGN:	Jack G. Ward
GEOTECHNICAL ANALYSIS:	Steven R. Van Fleet
SURVEYING AND MAPPING	for Donald Thrower
ENVIRONMENTAL STUDIES:	Susan Ivester Rees
CULTURAL RESOURCES:	Dorothy H. Gibbens
SOCIO-ECONOMIC ANALYSIS:	Evelyn H. Brown
CONSTRUCTION COST ESTIMATES:	Joseph H. Ellsworth, Jr.
DREDGING COST ESTIMATES:	Patricia A. Flanagan
REAL ESTATE MATTERS:	Larry V. Meese
	J. Ashford Kettler, Jr.

US Army Corps of Engineers
Mobile District
South Atlantic Division

WE'RE PROUD TO SIGN OUR WORK

PREFACE

The US Army Engineer Waterways Experiment Station (WES) was authorized to conduct this study by the US Army Engineer District, Nashville (ORN), by Intra-Army Order for Reimbursable Services Nos. 77-31 and 77-112. This report is Volume 5 of a 5-volume set which documents the seismic stability evaluation of Alben Barkley Dam and Lake Project. The 5 volumes are as follows:

Volume 1: Summary Report

Volume 2: Geological and Seismological Evaluation

Volume 3: Field and Laboratory Investigations

Volume 4: Liquefaction Susceptibility Evaluation and Post-Earthquake Strength Determination

Volume 5: Stability Evaluation of Geotechnical Structures

The work in this volume is a joint endeavor between ORN and WES. Mr. Paul F. Bluhm, of the Geotechnical Branch (CE-ORNED-G) at ORN, coordinated the contributions from ORN. Mssrs. Ronald E. Wahl of Soil and Rock Mechanics Division, Richard S. Olsen, and Dr. M. E. Hynes of the Earthquake Engineering and Geophysics Division (EEGD), Geotechnical Laboratory (GL), WES, coordinated the work by WES. The preliminary stages of this project were directed by Dr. William F. Marcuson, III, who was Principal Investigator from 1976 to 1979. From 1979 to 1988, Dr. M. E. Hynes-Griffin was Principal Investigator. Mr. Wahl was Principal Investigator from 1988 to project completion. Significant engineering support was provided by Mr. Donald E. Yule of EEGD. Additionally, Ms. Charlotte Caples, Mr. Daniel Habeeb, and Mr. Melvin Seid provided valuable assistance in the preparation of this report.

Overall direction at WES was provided by Dr. A. G. Franklin, Chief, EEGD, and Dr. Marcuson, Chief, GL.

Overall direction at ORN was provided by Mr. James E. Paris, Chief, Soils and Embankment Design Section, Mr. Marvin D. Simmons, Chief, Geology Section, and Mr. Frank B. Couch, Jr., Chief, Geotechnical Branch. Mr. Rick Connor is Chief, Engineering Division. LTC Stephen M. Sheppard is District Commander of ORN. Technical Advisors to the project were the late Professor H. B. Seed (University of California, Berkeley), Professors Alberto Nieto (University of Illinois, Champaign-Urbana) and L. Timothy Long (Georgia Institute of Technology), and Dr. Gonzalo Castro (Geotechnical Engineers, Inc.).

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander and Deputy Director was COL Leonard G. Hassell, EN.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
acre-feet	1,233.489	cubic metres
cubic feet	0.02831685	cubic metres
cubic yards	0.7645549	cubic metres
degrees (angle)	0.01745329	radians
feet	0.3048	metres
feet per mile	0.1893935	metres per kilometer
inches	2.54	centimetres
kips (force) per square foot	47.88026	kilopascals
miles (US statute)	1.609347	kilometres
pounds (force) per square foot	47.88026	pascals
pounds (force) per square inch	6.894757	kilopascals
square miles	2.589998	square kilometres
yards	0.9144	metres

SEISMIC STABILITY EVALUATION OF ALBEN BARKLEY LOCK AND DAM PROJECT

STABILITY EVALUATION OF GEOTECHNICAL STRUCTURES

PART 1: INTRODUCTION

Background

1. This report is Volume 5 of a five volume set that documents the investigations and results of a seismic stability evaluation of the Alben Barkley Lock and Dam Project, located on the Cumberland River, approximately 25 miles upstream of Paducah, Kentucky. This seismic safety evaluation was performed as a cooperative effort between the US Army Engineer Waterways Experiment Station (WES) and the US Army Engineer District, Nashville (ORN), and in accordance with Engineering Regulation 1110-2-1806.

2. Construction of the Barkley Project began in 1957 and was completed in 1966. As a key unit in the comprehensive plan of development of the Cumberland River, the multi-purpose Barkley Project provides flood control, hydroelectric power, navigation, and recreation. The reservoir is contained by a concrete gravity section flanked by earth embankment dams. The concrete gravity dam, powerhouse and lock system is 109 feet tall at maximum section. The embankment dams are founded on an alluvial deposit with a maximum thickness of approximately 120 feet. The alluvial deposit is underlain by Mississippian limestone. The alluvium, a complex layering of clays, silts, sands, and gravels, is the focus of concern in the seismic safety assessment due to the possibility of liquefaction of these sediments during an earthquake. The dam supports a railroad track system which traverses most of the dam crest. A canal, large enough for barge traffic, connects Barkley and Kentucky Lakes about 2.5 miles upstream from the dam. At the maximum flood control pool, elevation 375 feet, the reservoir stores 2,082,000 acre-feet, with 13 feet of freeboard (minimum crest elevation 388 feet). For normal operation, the pool elevation varies from 354 to 359 feet, and stored volume varies from 610,000 to 869,000 acre-feet, respectively. A pool elevation of 360 feet was used for the seismic stability evaluation. A location map and plan of the project are shown in Figure 1.

3. A summary of the major elements for this project are contained in Volume 1 (Wahl and Bluhm, 1992). Detailed information for each of these major elements are contained in four additional volumes. The geological and seismological investigations for the project are documented in Volume 2 (Krinitzsky, 1986) of this report series. The most severe seismic threat was determined to be an earthquake of body-wave magnitude, m_b, of 7.5, at a distance of about 118 km, in the New Madrid source zone. The earthquake motions estimated to occur at Barkley from an earthquake occurring in this source zone are a horizontal peak acceleration of 0.24 g, a peak velocity of approximately 35 cm/second, and a duration above 0.05 g of approximately 60 seconds.

4. Volume 3 (Olsen, et al. 1989) of this report series describes the results of the field and laboratory investigations which provided the information to estimate the response of the dam and foundation to earthquake ground motions, to measure the resistance to liquefaction of the soils in the alluvial foundation and to provide sufficient stratigraphic detail so that the areal extent of possible problem zones could be estimated.

5. The dynamic site response analysis in which the earthquake-induced shear stresses in the foundation alluvium are computed and the investigations made to determine the extent of liquefaction expected in the alluvial foundation are documented in Volume 4 (Wahl, et al, 1992). In addition, the post-earthquake strengths of the materials which were input to the post-earthquake slope stability analysis, were also reported and discussed in Volume 4.

6. This volume evaluates the post-earthquake slope stability of the dam and is based on the results of the liquefaction and post-earthquake strength investigations which were reported in Volume 4. Two sections of the dam were evaluated, one representing the main embankment and a second that cuts through the switchyard area and exits into the tailrace channel. The results of the field and laboratory investigations, the extent of liquefaction in the foundation and the residual strengths of the materials determined in Volumes 3 and 4 are used as input to the slope stability analysis. The final deformations and configurations of the dam were estimated from the results of the liquefaction, stability analyses, and comparisons to case histories.

PART II: EMBANKMENT SECTIONS ANALYZED

Main Embankment Section

7. The main part of the right embankment, from station 44+00L to the right abutment, is a homogeneous, rolled-earth, compacted impervious fill with a horizontal downstream drainage blanket. Figure 2 shows a detailed section of the main embankment. The upstream slopes are 1 vertical to 2.5 horizontal from the upstream toe of the dam to elevation 380 feet, and 1 vertical to 2 horizontal from elevation 380 feet to the top of the dam, elevation 388 feet. The crest of the dam, which supports a railroad track is 38 feet wide. The downstream slopes are 1 vertical to 2 horizontal from the dam crest to elevation 375 feet, and 1 vertical to 4.5 from this elevation to the downstream toe of the slope. A two-foot thick drainage blanket extends from 20 feet downstream of the dam's centerline to a rock toe drainage ditch. A ten-foot wide, five foot deep key trench, with 1 vertical to 1 horizontal side slopes keys the dam to the foundation. As was described in Volume 3 of this series of reports, the alluvial foundation is divided into three Units. Unit 1 consists of a medium stiff clay which extends from the ground surface to elevation 325 feet, a thickness of 15 to 20 feet. Underlying this to elevation 300 feet is Unit 2 where the materials susceptible to liquefaction are present. These materials consists of a highly stratified sequence of clays, silts, and sands as well as mixtures of silty sands and sandy clays. Denser sands are present below elevation 300 feet and make up Unit 3.

Switchyard Section

8. A switchyard and access roads are located downstream of the centerline of the dam from the powerhouse to station 44+00L. A typical section through the switchyard is shown on Figure 3. On the upstream side of a typical section is a 1 vertical to 30 horizontal random fill berm which starts at the ground surface and extends to elevation 350 feet. From this point the slope is 1 vertical to 2.5 horizontal to elevation 381 feet and 1 vertical to 2 horizontal from this elevation to the dam's crest. The top elevation of the dam varies from 394.5 feet at the power house to elevation 389.2 feet at station 44+00L, and the crest is 24 feet wide. On the downstream side, the slope is 1 vertical to 2.5 horizontal from the crest to a 20-foot wide access road which leads to the top

of the dam. From here the slopes are 1 vertical to 1.75 horizontal to the switchyard which has a surface elevation of 366 feet. The switchyard is 275 feet wide and meets the existing ground at elevation 345 feet with a 1 vertical to 2.5 horizontal slope. An inclined drain, which starts at the centerline at elevation 370 feet and is 9 feet wide (horizontal measurement) was added to control seepage in this area. It has a slope of 1 vertical to 1.5 horizontal and connects to a horizontal drainage blanket. As described previously in Volumes 1 through 4, the alluvial foundation is divided into three units, with Unit 2 being the zone most susceptible to liquefaction. Extensive exploration in this area shows that Unit 1 extends from the surface to elevation 320 feet, Unit 2 from elevation 320 to 305 feet, and Unit 3, which is subdivided into three zones, A, B and C, from elevations 305 feet to the top of rock. Unit 3A is located between elevations 305 and 295 feet and consists of dense sands and gravels interbedded with thin layers of clay. Between elevation 295 and 288 feet is Unit 3B which consists of a soft clay layer that appears to be continuous across the site. This clay layer is interbedded with thin layers of sand. Below elevation 288 feet are denser sands which make up Unit 3C. This part of the embankment is also keyed to the foundation with a trench that is about 23 feet in depth. A sheetpile cutoff was driven through the natural alluvium to rock and a grout curtain was constructed from stations 33+81L to 38+52L. Retaining walls were built upstream and downstream of the powerhouse, parallel to the direction of flow, to protect the embankment dam and its alluvial foundation from erosion. Figures 4 and 5 show sections of the sheetpile cutoff, grout curtain and retaining walls.

PART III: PRE-EARTHQUAKE CONDITIONS

Sections Analyzed

9. Stability analyses were performed on two sections of the dam, one for the main embankment and the other through the switchyard. A plan view showing the location of these sections is shown in Figure 6 and typical cross sections through the main embankment and switchyard are shown on Figures 2 and 3, respectively. Circular failures were assumed for the section through the main embankment. Geometry of the dam and foundation dictated that circular failures be assumed because the free field beyond the toe of the dam extends for a large distance and Unit 2 does not daylight as it does in the switchyard area. Critical wedge failure surfaces approximate a circular surface and therefore were not used. In the switchyard section a wedge type failure is assumed to occur, exiting into the tailrace channel. This section is curved section in plan, cutting through the embankment and curving toward the tailrace channel.

Material Properties

Embankment Material Properties

10. The material properties for the embankment and switchyard were determined from the results of tests reported for construction record samples (Reference 8) and from recent laboratory and in-situ tests performed on samples from borings made for the seismic analysis (see Volume 3). From field densities measured during the construction of the dam, the average moist and saturated unit weights were calculated to be 126 and 128 pounds per cubic foot, respectively. Strength test results were also reported for the samples taken for construction records and performed for samples from recent borings. Figures 7 and 8 show strength envelopes estimated from results of the triaxial tests performed on the embankment materials. The values were selected to represent the embankment strengths prior to the earthquake. Table 1 summarizes these parameters. The shear strength parameters for the random fill represent conservative values as described in the original Design Memorandum 3C.

Foundation Material Properties

11. In the stability analysis, the soil parameters for the three units of the foundation were determined from reported results of tests performed on samples obtained prior to construction of the dam and also from tests on samples

from the recent borings made in connection with the seismic analysis. Table 1 summarizes these parameters which represent the estimated strengths prior to the postulated design earthquake. Figures 9 and 10 give the strength envelopes estimated from results of the triaxial tests for Unit 1 (clay) of the foundation. Unit 2 , which is dominated by soft clays interbedded with thin layers of sand, is subdivided into these two materials (clay and sand), and the strength of each material is given in Table 1. Figures 11 and 12 give the strength envelopes estimated from the results of the triaxial tests performed on the soft clays and Figure 13 give the strength envelopes estimated from the results of the direct shear tests performed on the sands. No tests were performed on the dense sands and gravels of Units 3A and 3C on the right bank. However, tests were performed on samples taken in this zone on the left bank (Reference 10) and evaluations made in Design Memorandum 3C indicate that these materials were similar to Unit 3A and 3C. Therefore, these strength values were used and no additional tests were made. Tests were not performed on the soft clays in Units 3B and their strengths were assumed to be the same as those of the clays in Unit 2 because the Cone Penetration Test (CPT) values of both units were similar.

Piezometric and Pool Levels

12. The piezometric and normal pool levels are discussed in detail in Volume 3 of this series of reports and are briefly discussed in this Volume. For the two sections analyzed the upstream pool was assumed to be at elevation 360 feet. For the main part of the dam, a straight upper piezometric line was assumed to pass from the pool elevation through the dam to the drainage blanket and a ground water elevation of 345 feet was assumed beyond the downstream toe. In the switchyard section, the upper piezometric line of seepage was assumed to pass from the pool elevation, through the dam to the inclined drain, then down to the tailwater elevation of 305 feet. The corresponding piezometric lines for the two sections analyzed are shown in Figures 2 and 3.

PART IV: POST-EARTHQUAKE CONDITIONS

Main Embankment Cross Section

Embankment and Unit 1 Post-earthquake Strengths

13. No laboratory cyclic strength tests were performed on samples from the embankment or Unit 1 of the foundation. However, work by Ellis and Hartman (1967) and Thiers and Seed (1968) shows that a strength loss of between 10 and 20% can be expected for clayey materials whose peak cyclic strain is about half of its failure strain in a static test. Therefore, the assumption was made these materials would experience a 20% reduction in their strengths after the earthquake motions had ceased. Table 1 gives the reduced strength values.

Foundation Unit 2 Post Earthquake Strengths

14. General: As was discussed in Volume 4, the sand components (fine sand, silty sand and sandy silt) of Unit 2 of the foundation are the materials most susceptible to liquefaction, high strains, and severe strength loss. In the stratigraphy analysis (Volume 3) it was conservatively concluded that the sand components were continuous. The clay component in Unit 2 was determined to be non-liquefiable.

15. Strength of Liquefied Zone: The liquefaction analysis from Volume 4 indicates that liquefaction would occur both in the free field and under the dam, although the analysis indicates that liquefaction will not occur under the slopes of the embankment as shown in Figure 14. As discussed in Volume 4, the N_{1eff} (fines corrected blowcount used to determine the undrained residual strength of a liquefied soil) of this zone is 17.5 which corresponds to an estimated residual strength of 700 psf.

16. Strength of Non-Liquefied Zone: Although the materials in this zone are predicted not to undergo liquefaction, they will have some strength reduction due to the generation of earthquake induced excess pore pressure, ru, which is defined as the ratio of the excess pore pressure, u_e, to the effective overburden pressure, σ_v' ($r_u = u_e/\sigma_v'$). The liquefaction analysis indicated that the factors of safety were generally close to 1.1 in this zone. At a factor of safety of 1.1, excess pore pressures are expected to be greater than 50%. Therefore, it was assumed that in this zone a residual strength of 700 psf would also be used.

Foundation Unit 3 Post-Earthquake Strength

17. General: Liquefaction is not expected to occur under the main embankment in Unit 3, however liquefaction is expected to occur beyond the toes of the embankment between elevation 295 and 285 feet. Below elevation 285 feet liquefaction is not expected to occur. Under the main embankment the excess pore pressures in Unit 3 will result in a decrease in strength although not as severe as that in Unit 2. Figure 14 shows the location of the zones of liquefaction and the estimated boundaries between the zones of liquefaction and non-liquefaction.

18. Strength of Liquefied Zone: In Unit 3, the N_{1eff} is 25 blows/ft. As recommended in Volume 4, an estimated residual strength of 800 psf was assigned to Unit 3. The residual strength of Unit 3 is significantly higher than the residual strength of Unit 2.

19. Strength of Non-Liquefied Zone: The liquefaction analysis indicated that the factor of safety was 1.25 or greater except for small isolated zones. At a factor of safety of 1.25, excess pore pressures are expected to be about 30%. Therefore, an estimate of 50 percent was conservatively used for the excess pore pressures in the stability analysis.

Switchyard Cross Section

Embankment and Unit 1 Post-Earthquake Strength

20. The post earthquake strengths used for the main embankment and Unit 1 cross section were assumed to be the same for the switchyard section as described in Paragraph 13.

Foundation Unit 2 Material Properties

21. General: It was determined from the liquefaction analysis that liquefaction would occur in the free field and under portions of the switchyard area but not underneath the dam although underneath the dam excess pore pressures will also result in a decrease in strength. Figure 15 shows the locations of the zones of liquefaction and the estimated boundaries between the zones of liquefaction and non-liquefaction.

22. Strength of Liquefied Zone: The materials in the liquefied zone have an average N_{1eff} of 15.5 which corresponds to an estimated residual strength of 450 psf as discussed in Volume 4.

23. Strength of Non-Liquefied Zone: As established by criteria discussed in Volume 4, the strength of the non-liquefied zone will be controlled by the clays, and a strength to effective overburden pressure (c/p) ratio of 0.31 was assumed. Using the same rationale as in paragraph 13, this was reduced by 20%, for a c/p = 0.25.

Foundation Unit 3 Material Properties

24. General: As was discussed in Paragraph 8, in the switchyard area this unit has been subdivided into three smaller units, A, B and C. As in Unit 2, the liquefaction analysis also determined that liquefaction would occur in the free field and under some areas of the switchyard in Unit 3A and only in the free field in Unit 3C. Figure 15 shows the location of the zones of liquefaction and the estimated boundaries between the zones of liquefaction and non-liquefaction.

25. Strength of Liquefied Zone: In Units 3A and C, the N_{1eff} is 25.5 which, corresponds to a residual strength of 800 psf, significantly higher than that in Unit 2.

26. Strength of Non-Liquefied Zone: As was the case for Unit 2, the materials in Units 3A and C are predicted not to undergo liquefaction, although they will have some strength reduction due to generation of excess pore pressures. In Unit 3A the pore pressure ratios are expected to reach 35 percent beneath the center of the dam. In Unit 3C, the pore pressures ratios vary from 20 percent beneath the dam to 50% in the switchyard area. However, a value of 50 percent was used for the entire zone.

27. Strength of Unit 3B Clay: The clays in Unit 3B are expected to undergo large strains. No strength tests were performed on this material because none were sampled as they were not thought to be of any concern in the liquefaction analysis. As indicated in Volume 4 the results of the CPT program indicate that these materials behave like a normally consolidated clay. This would correspond to a strength to overburden ratio (c/p) of 0.31. Using the same rationale as in Paragraph 13, this was reduced by 20%, for a c/p value of 0.25.

PART V: STABILITY ANALYSIS

Method of Analysis

28. The stability analysis was performed using the computer program UTEXAS2. This program has four methods of analysis, Spencer's, simplified Bishop's, modified Swedish, and Lowe and Karafiath's from which to select. Spencer's method was used in this study as it satisfies complete static equilibrium for each slice and it also has the capability of computing factors of safety for both circular and planar surfaces. It was assumed that the embankment had reached a steady state seepage condition when the earthquake occurs which corresponds to a consolidated undrained condition for laboratory analysis.

Pre-Earthquake Embankment Stability

29. For comparison purposes, the stability of both the main embankment and the switchyard section were evaluated using the soil parameters listed in Table 1 to arrive at the final minimum failure surfaces as discussed in the following paragraphs. The results are shown in Table 2.

Post-Earthquake Embankment Stability

30. The problems of predicting or estimating deformations of an embankment following liquefaction of the foundation are difficult and not well defined. Predicting deformations which occur due to liquefaction and the effects of both static and inertial forces acting on an embankment are problems that are probably beyond the current state-of-the-art in geotechnical engineering. Analogy and empiricism were used to determine the residual strengths in the foundation. Reasonable assumptions regarding the strain levels required for liquefaction were used to estimate the deformations in the embankment cross-sections. However, deformations in this case were estimated by analogy to observed embankment and foundation deformations reported by Seed, Lee, Idriss and Makdisi (1975) and Seed (1987).

Conditions and Assumptions of Analysis

31. The stability and deformations of the embankment for Barkley Dam were therefore evaluated based on the following conditions.

32. Liquefaction (defined as a condition where the pore pressure ratio, ru - 100 percent) of the foundation occurs near the end of the earthquake. This is assumed to occur when the computed factor of safety against liquefaction is close to one and the results of the analysis given in Volume 4 shows the zones where it will occur. Only static stresses will be acting on the embankment and deformations can be estimated for this condition.

33. The entire critical zone defined by the liquefaction analysis is assumed to have liquefied (see Figures 14 and 15 for location of liquefied zones). This is conservative, as explorations and the downstream river bank exposure indicates that this zone is dominated by soft clays, interbedded with thin layers of sand, which were assumed to be continuous. Liquefaction was also assumed to have occurred in the free field beyond the switchyard area between elevation 305 feet and 295 feet and below elevation 288 feet in the switchyard area.

34. For the main embankment section, circular failure surfaces were assumed. Assuming that the entire identified foundation zone has liquefied is conservative as the failure circles must pass through the soft clays.

35. In the switchyard section, it was assumed that a continuous sand layer can exist at any elevation interval in the liquefied zone. A wedge type of analysis was used in this area and a failure plane was assumed to occur through the embankment and along the sand layer exiting into the tailrace canal.

Procedure

36. Evaluating the stability of the embankment under the above conditions can be complex. Accordingly, Seed (1987) proposed the procedure in the following paragraphs for evaluating the stability of structures after liquefaction has occurred in the foundation.

37 Assume first that the full residual strength of the liquefied soil is mobilized. If the computed factor of safety is less than or close to 1.0, then sliding and unacceptably large deformations are expected. For Barkley Dam this would be failure of the dam and loss of the reservoir.

38. If, in the condition described in Paragraph 37, the safety factors against sliding with full residual strength are greater than 1.0 and failure of the dam does not occur, then assume that the strength in the liquefied zone is zero. If, using zero strength in the liquefied zone, the factor of safety from

a stability analysis is significantly greater than one (a factor of safety of 1.2 is considered "significantly greater" for Barkley for this case), then the stability of the embankment is controlled by the nonliquefied soil and the deformations of the embankment will be small (i.e. less than 5 to 6 feet).

39. If, in the condition described in Paragraph 38, the factor of safety is not significantly greater than one (i.e. 1.2), then the residual strength required to be mobilized to produce a stable condition (a stable condition is defined as a condition having a factor of safety of 1.2) should be computed. If the residual strength estimated from empirical or laboratory methods is less than the residual strength required, then large scale deformations will occur and it is not possible to accurately predict the final configuration of the embankment. If, however, the estimated residual strength is sufficient to produce a stable condition, then the shear strain which would have to develop in the liquefied soil in order to mobilize this resistance could be estimated. Knowing this strain, the potential deformation of the embankment could be evaluated. This can then be compared to the available freeboard of 28 feet.

Results of the Analysis

40. Based on the assumptions and procedure outlined in Paragraphs 31 through 39, slope stability analyses were performed on the two typical sections. Table 3 gives the strengths of the materials used.

41. Main Embankment: When a zero strength was assumed in the critical zone as defined by the liquefaction analysis, the resulting minimum factors of safety for the upstream and downstream slopes were both 0.7 with the minimum circles tangent to a plane at elevation 300 feet (see Figure 16). Using the full residual strength of 700 psf for the liquefied soil produced factors of safety of 1.3 for both the upstream and downstream slopes (see Figure 17). (By comparison, the pre-earthquake safety factors for both the upstream and downstream failure surfaces were 3.2). Thus, according to Paragraph 37, sliding and large scale deformations are not expected to occur however, both the upstream and downstream portion of the main dam are expected to undergo large strains. Seed has estimated that the strains required to mobilize the full residual strength are about 25% (See Seed's letter dated February 3, 1986 in Appendix A of Report 1).

42. Switchyard Section: Because liquefaction can occur in Units 2, 3A and 3C, stability analyses were performed on failure planes at elevations of 305, 295 and 288 feet (the search routine on the computer program found that the critical failure planes for this units corresponded to the base elevations of the these Units). As outlined in Paragraph 37, the full residual strength was used for the liquefied zones and the minimum factors of safety were determined for the failure planes at the three elevation intervals. The minimum failure planes are shown in Figures 18-23.

43. Using the full residual strength of 450 psf, the minimum failure plane occurs at elevation 305 feet with factors of safety of 1.6 and 1.8 for the downstream and upstream slopes, respectively. Therefore, large scale movements and deformations are not anticipated in this area. However, using zero strength in the critical zone for failure plane elevations of 305 feet will result in factors of safety less than one for both the upstream and downstream conditions (0.8 and 0.7, respectively). Analyses were then performed assuming that the dam has strained and the residual strength required to produce a stable condition (factor of safety = 1.2) was determined. For the minimum failure planes at this elevation, a residual strength of about 200 psf is needed to produce a stable condition for the upstream slope and 250 psf for the downstream slope, which is less than the estimated maximum residual strength of 450 psf of the soil. The pre-earthquake safety factors for the upstream and downstream surfaces are 4.4 and 5.6, respectively. Figures 18-19 shows the location of the failure surfaces and Table 2 summarizes the results.

44. Using the full residual strength of 1200 psf, the minimum failure surface at elevation 295 feet produced factors of safety of 3.8 and 2.6 for the upstream and downstream slopes, respectively, indicating that large scale movement and deformations are not anticipated. Using zero strengths in the liquefied zones produced factors of safety of 0.5 and 0.6 for the respective failure surfaces. For the minimum upstream and downstream failure planes, a residual strength of 200 and 250 psf, respectively, is needed for a stable condition. The pre-earthquake safety factors for the upstream and downstream surfaces are 4.4 and 7.2, respectively. The minimum failure surfaces are shown in Figures 20 and 21 and Table 2 summarizes the results.

45. Using the full residual strength of 1200 psf, the minimum failure surface at elevation 288 feet produced factors of safety of 2.7 and 3.3 for the upstream and downstream slopes, respectively, indicating that large scale movement and deformations are not anticipated. Using zero strengths in the liquefied zones produced factors of safety of 0.5 and 2.5 for the respective failure surfaces. Because of the large non-liquefied zone under the switchyard, it contributed a large portion of the strength along the minimum failure plane and a high factor of safety. On the upstream side, the entire zone at this elevation was considered to have liquefied and with zero strength produced a safety factor less than one. For the minimum upstream failure plane, a residual strength of 200 psf is needed for a stable condition. The pre-earthquake safety factors for the upstream and downstream surfaces are both 5.2. The minimum failure surfaces are shown in Figures 22-23 and Table 3 summarizes the results.

46. Estimated Deformations: As mentioned previously, strains of 20 to 25 percent are required to mobilize the full residual strength. Since the thickness of the liquefied zone of Unit 2 along the main embankment is 25 feet and the zone consists of 20 percent sand, then 2 to 3 feet of horizontal movement can be expected. In the switchyard area where the primary zone of liquefaction is 15 feet thick and contains 20 percent sand, the expected horizontal deformations will be about 1 to 2 feet.

47. For both sections, the expected vertical deformations should be about of about the same order of magnitude or smaller as those for the horizontal component. The vertical movements can be attributed to other failure mechanisms activated by the earthquake such as bearing capacity and settlement.

Conclusions

48. Stability analyses were performed on two sections of the dam, one representing the main portion of the embankment and the second through the switchyard area, exiting into the tailrace channel. These stability analyses were based on procedures suggested by Seed (1987).
The results of this analysis indicate that wide scale deformations or slope failure which would result in loss of the reservoir are not expected. Deformations on the order of 2 to 3 feet can be expected on the slopes of the main portion of the dam (reference February 1986 letter from Dr. Seed, Appendix A). In the switchyard area deformations of about 1 to 2 feet can be expected,

but loss of the reservoir will not occur. These estimated deformations are relatively small in light of the fact that a freeboard of 28 feet is expected to be available at the time of the earthquake.

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TABLE 1

PRE-EARTHQUAKE SOIL PARAMETERS

SOIL TYPE	UNIT WEIGHTS (PCF)		R STRENGTHS		S STRENGTHS	
	MOIST	SAT	C (PSF)	PHI	C (PSF)	PHI
EMBANKMENT AND SWITCHYARD	126	128	1000	22	0	26.5
RANDOM FILL*	126	128	400	8.5	0	14.
UNIT 1 - CLAY	115	125	1200	15	600	22.
UNIT 2 - CLAYS	122	126	700	14	0	31.
SANDS	122	126	----	----	0	31.
UNIT 3A - DENSE SANDS AND GRAVELS*	126	128	200	35	300	35.
UNIT 3B - CLAYS	122	126	700	14	0	31.
UNIT 3C - DENSE SANDS AND GRAVELS*	126	128	200	35	300	35.

* INDICATES ESTIMATED VALUES FROM DESIGN MEMORANDUM - 3C.

TABLE 2

SUMMARY OF STABILITY ANALYSES

	Factors of Safety						Residual Strength Required (psf)	
	Preearthquake		Full Residual		Zero Strength			
	U/S	D/S	U/S	D/S	U/S	D/S	D/S	U/S
Main Embankment	3.2	3.2	1.3	1.3	0.7	0.7	---	---
Switchyard El 305	4.4	5.6	1.8	1.6	0.8	0.7	200	200
El 295	4.4	7.2	3.8	2.6	0.5	0.6	200	250
El 288	5.2	5.2	2.9	3.3	0.5	2.5	200	---

Note: Columns 2-7 are the factors of safety for the conditions given. The last two columns represent the residual strength in psf required to produce a factor of safety of 1.2 or greater.

TABLE 3

PARAMETERS USED IN POST EARTHQUAKE STABILITY ANALYSIS

SOIL TYPE	UNIT WEIGHTS (PCF)		STRENGTH		EXCESS PORE PRESSURE
	MOIST	SAT	C (PSF)	PHI	
EMBANKMENT AND SWITCHYARD	126	128	800	18	
RANDOM FILL	126	128	320	6	
UNIT 1 - CLAY	115	125	960	12	
UNIT 2 - LIQUEFIED ZONE RESIDUAL STRENGTH					
SWITCHYARD AREA	122	126	450	0	
MAIN EMBANKMENT AREA	122	126	700	0	
UNIT 2 - NON-LIQUEFIED ZONE	122	126	0.25P		
UNIT 3A - LIQUEFIED ZONE RESIDUAL STRENGTH	126	128	800	0	
UNIT 3A - NON-LIQUEFIED ZONE	126	128	0	31	35%
UNIT 3B - CLAY	122	126	0.25P		
UNIT 3C - LIQUEFIED ZONE RESIDUAL STRENGTH	126	128	800	0	
UNIT 3C - NON-LIQUEFIED ZONE	126	128	0	35	50%

P IS THE EFFECTIVE OVERBURDEN PRESSURE

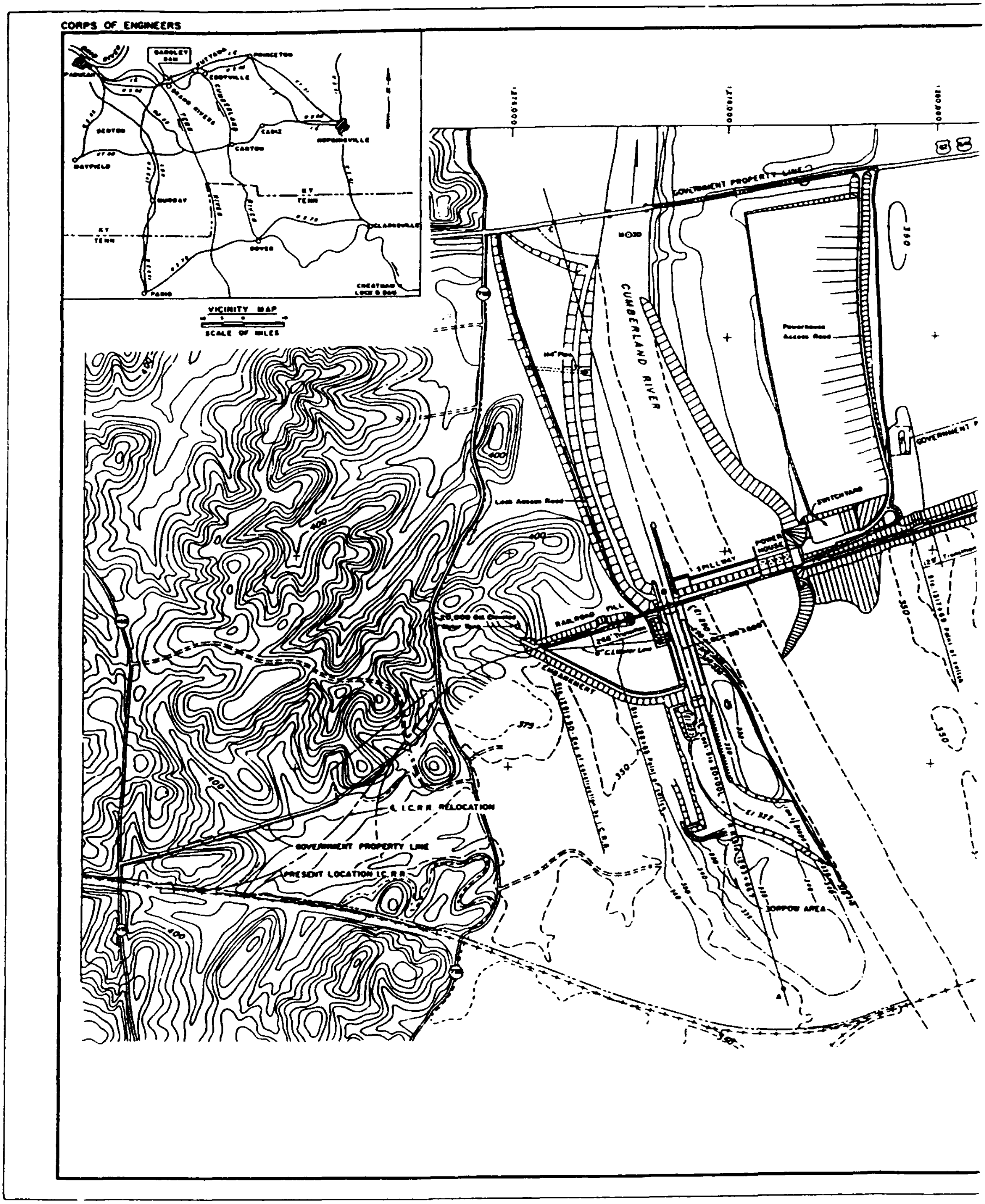
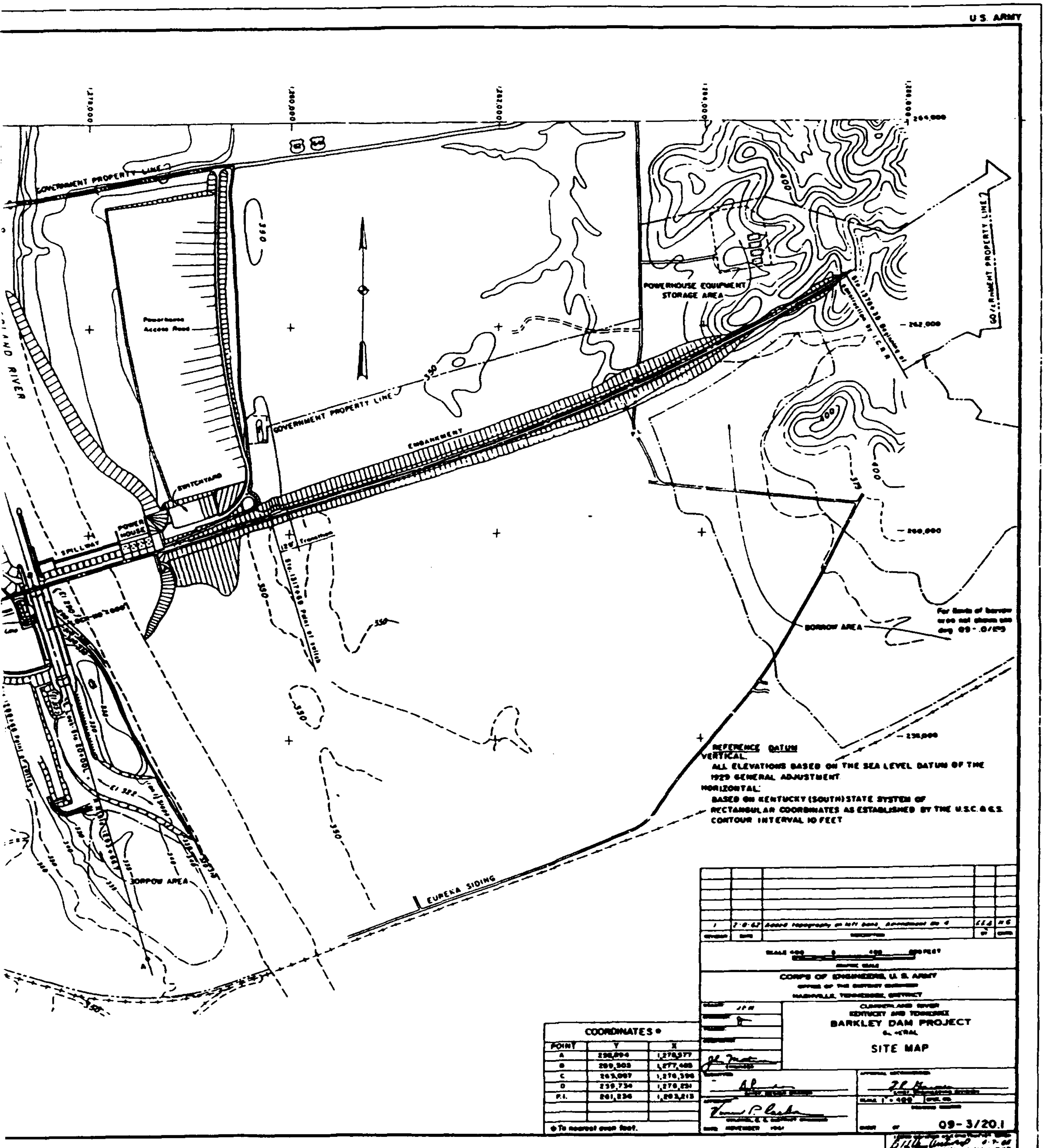


Figure 1. Plan view of the Barkley Lake



ı view of the Barkley Lake and Dam Project.

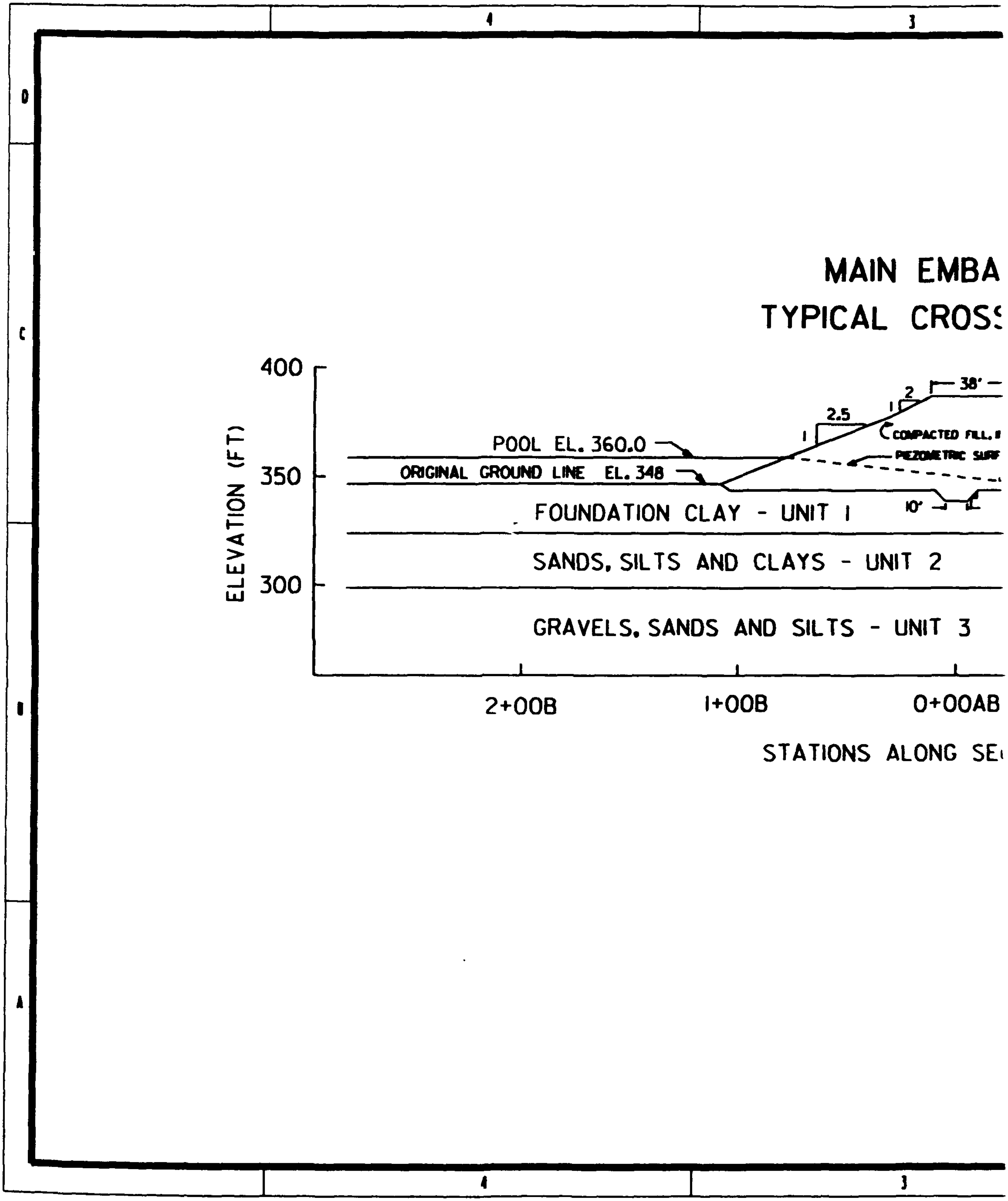
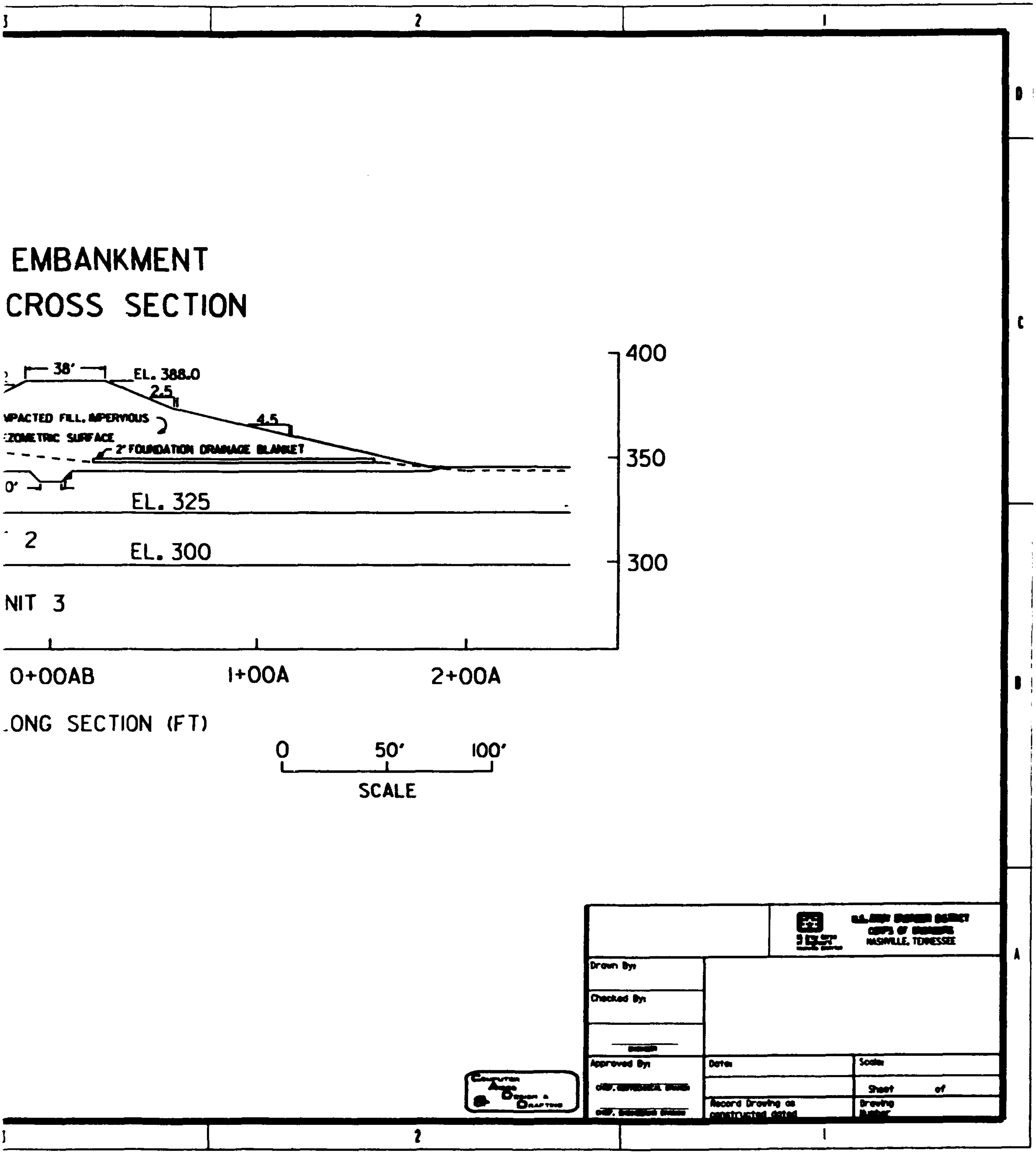


Figure 2. Main embankment - t



ment - typical cross section.

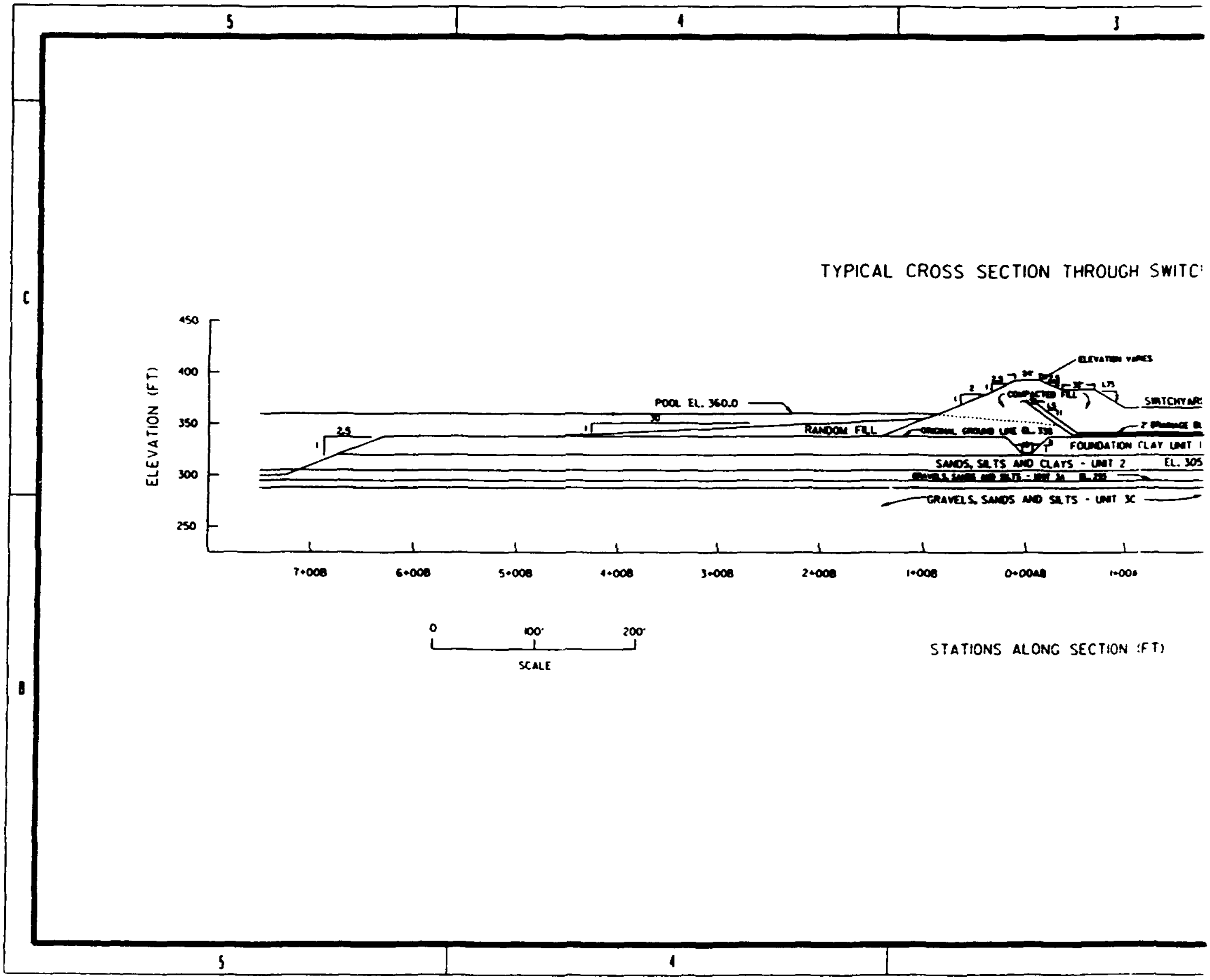
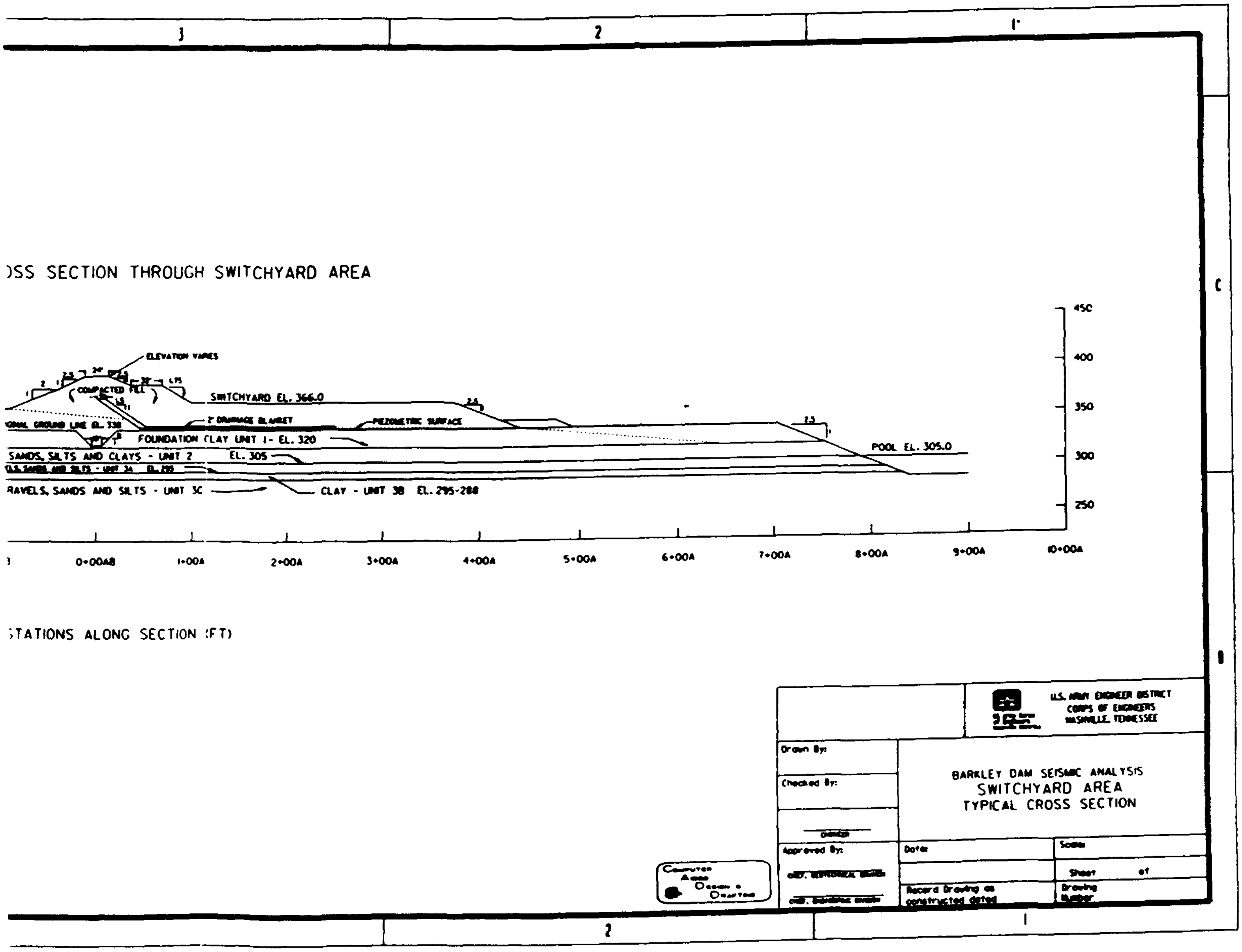


Figure 3. Typical cross sec



Typical cross section in switchyard area.

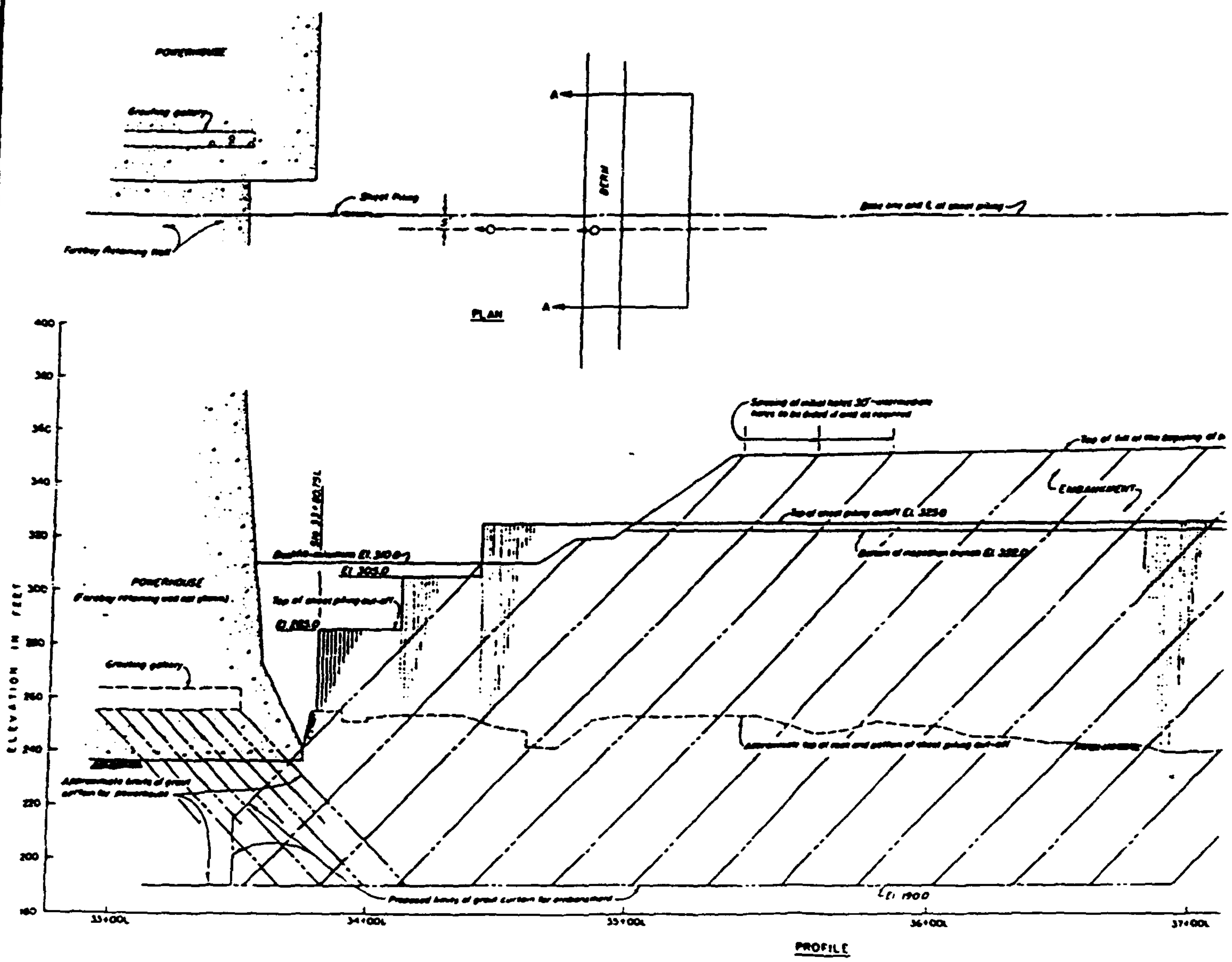
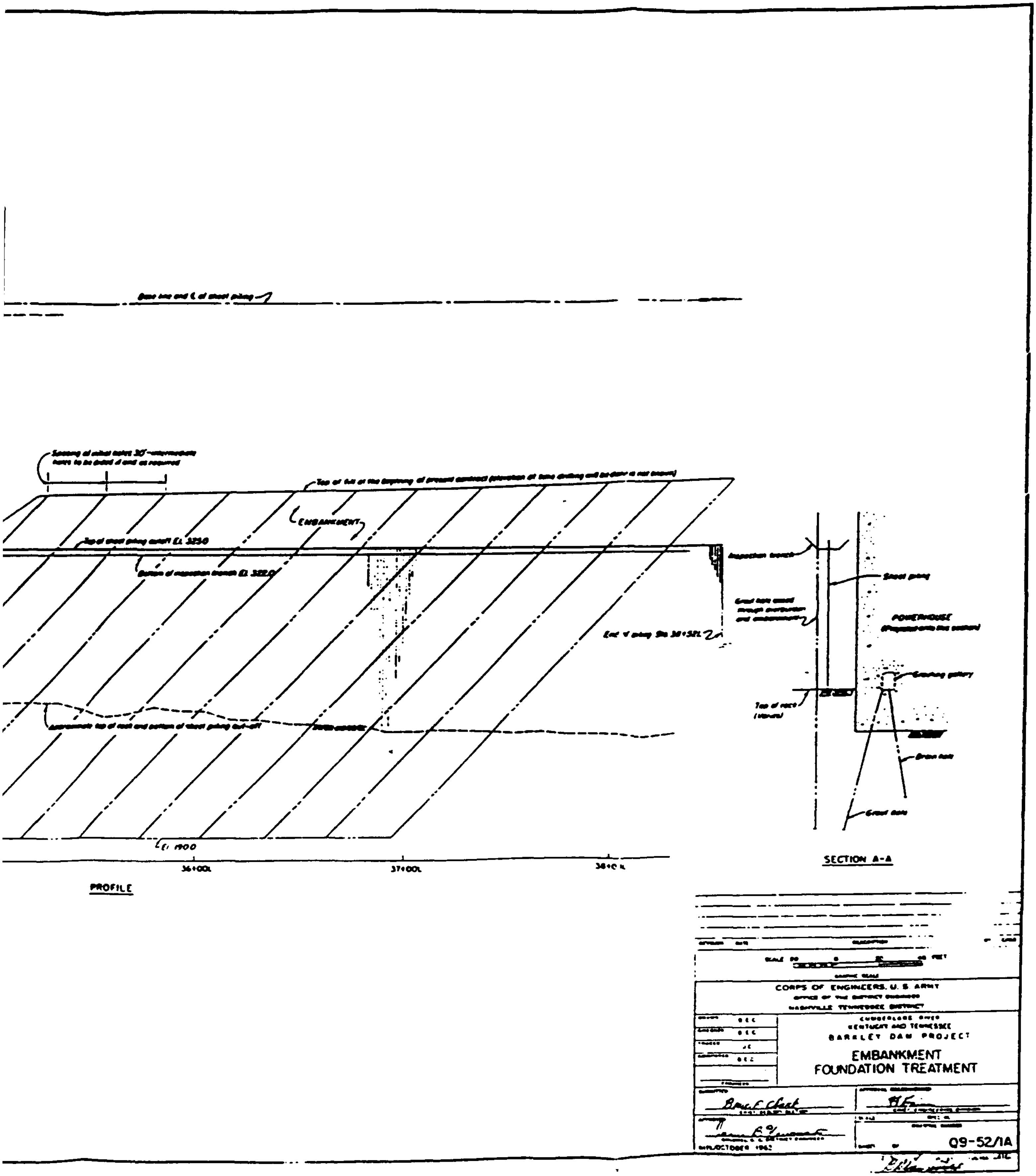


Figure 4. Details of grout curtain and sheetpile wal switchyard section.



of grout curtain and sheetpile wall in the switchyard section.

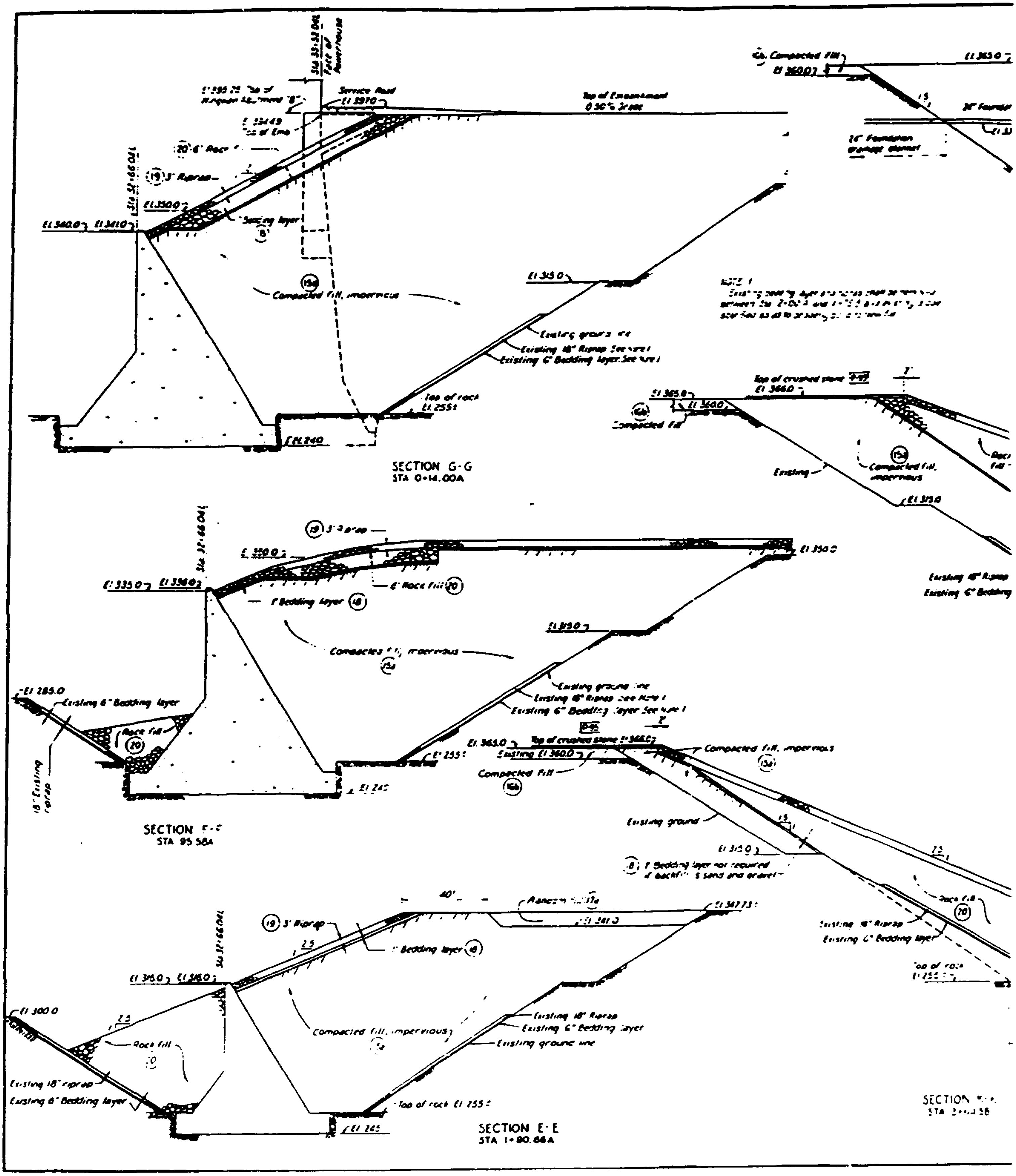
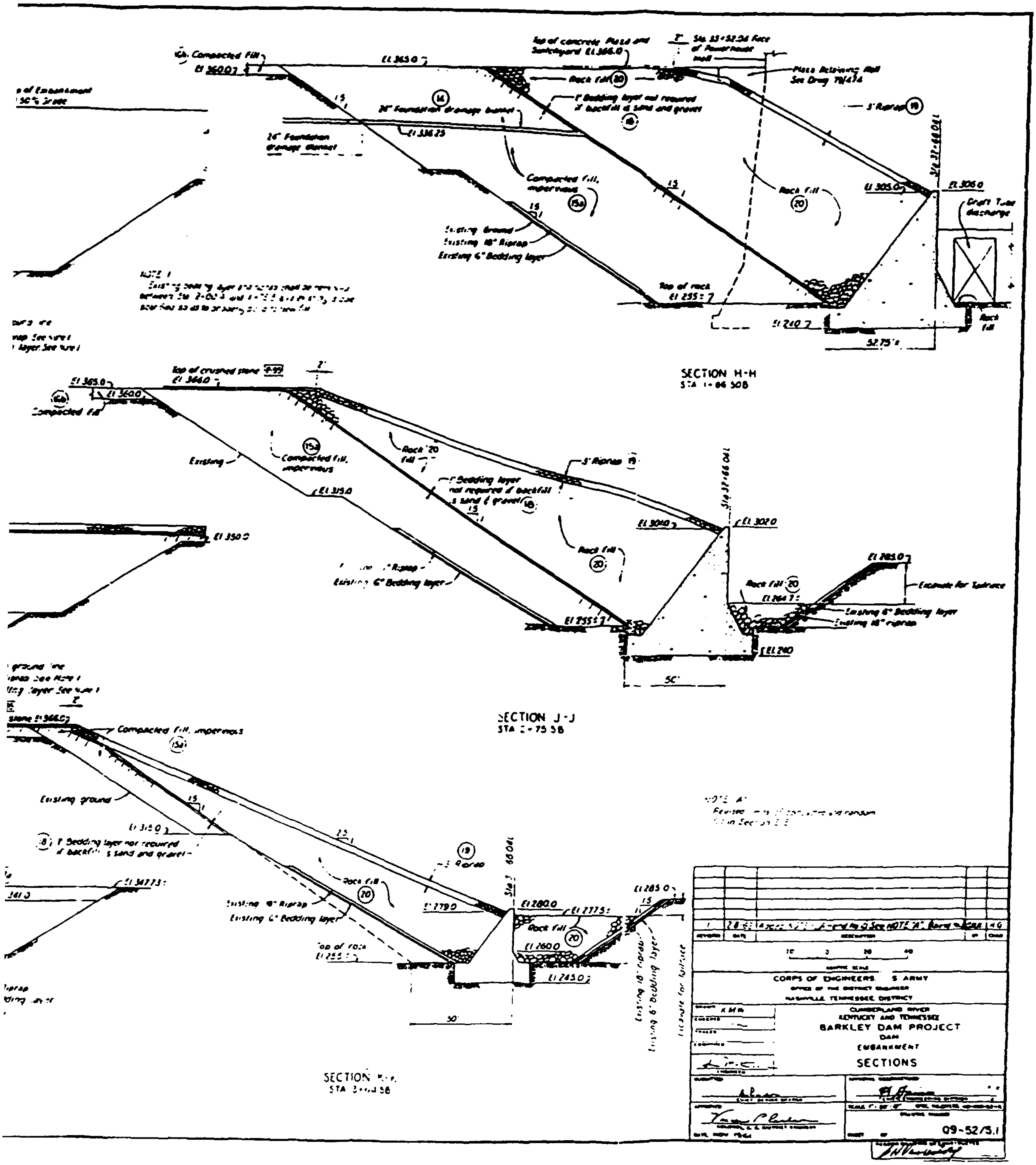


Figure 5. Upstream and downstream retaining walls n



and downstream retaining walls near powerhouse.

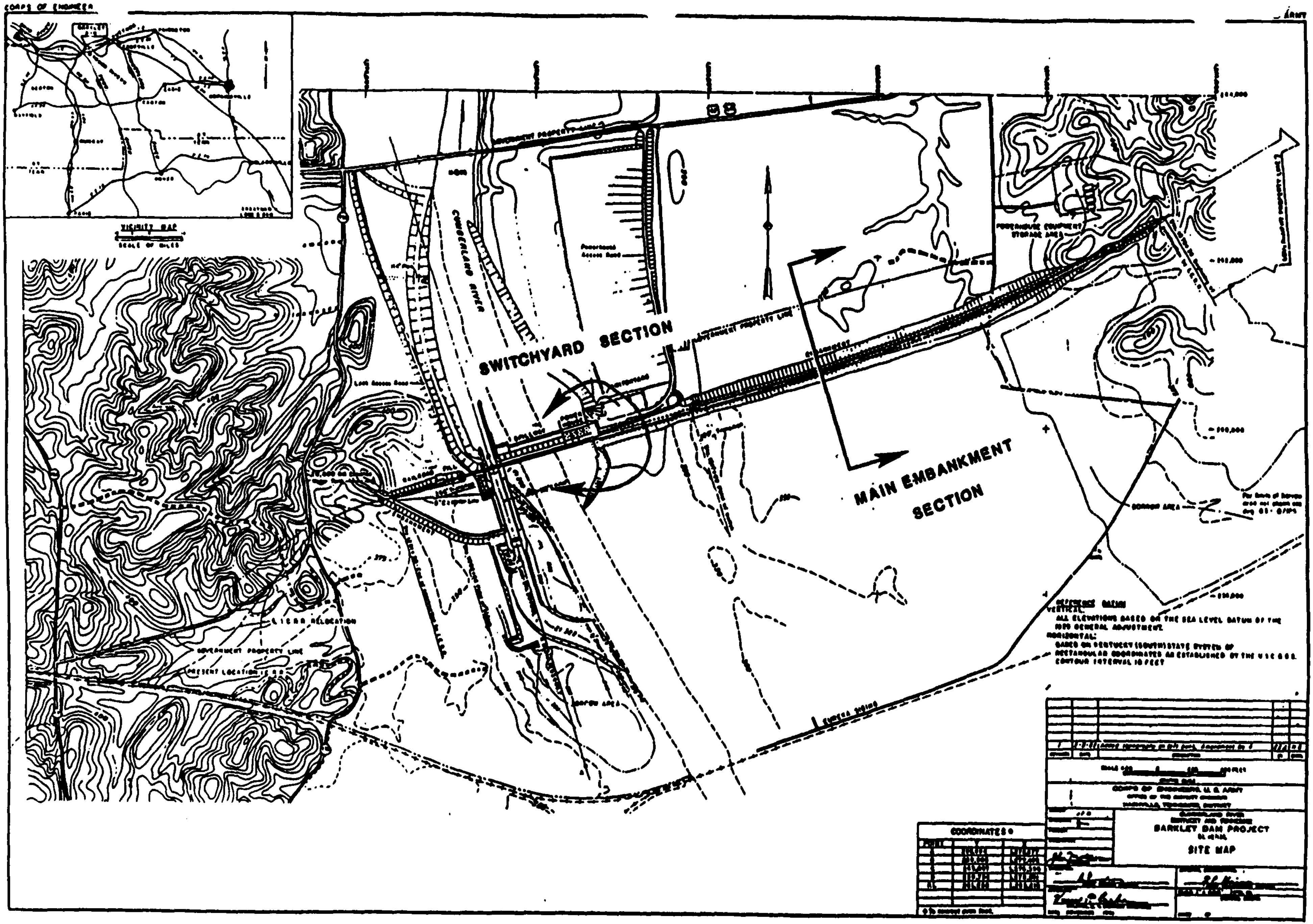


Figure 6. Plan view showing the locations of the analysis sections.

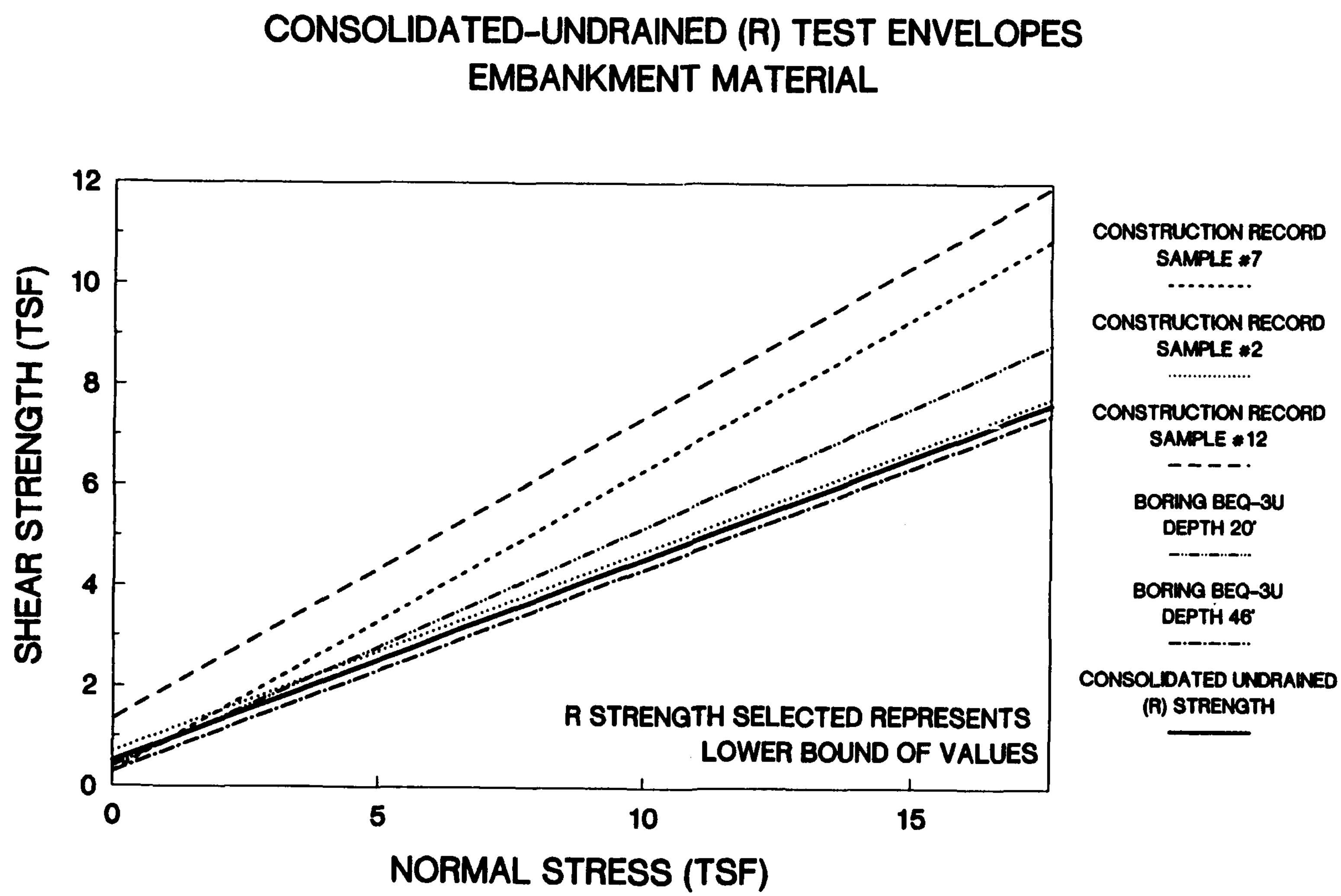


Figure 7. Consolidated - undrained (R) test envelopes for the embankment material.

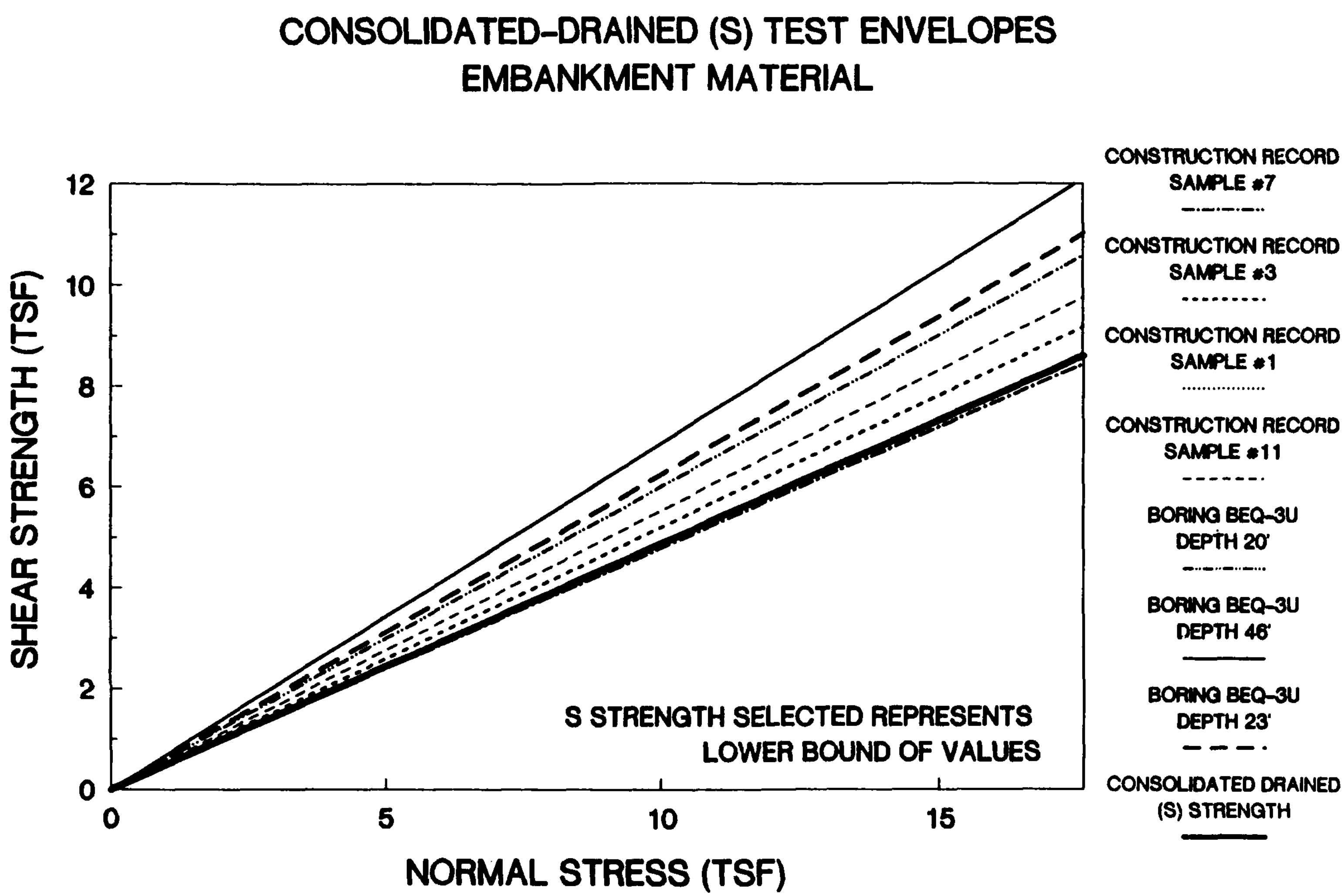


Figure 8. Consolidated - drained (S) test envelopes for the embankment material.

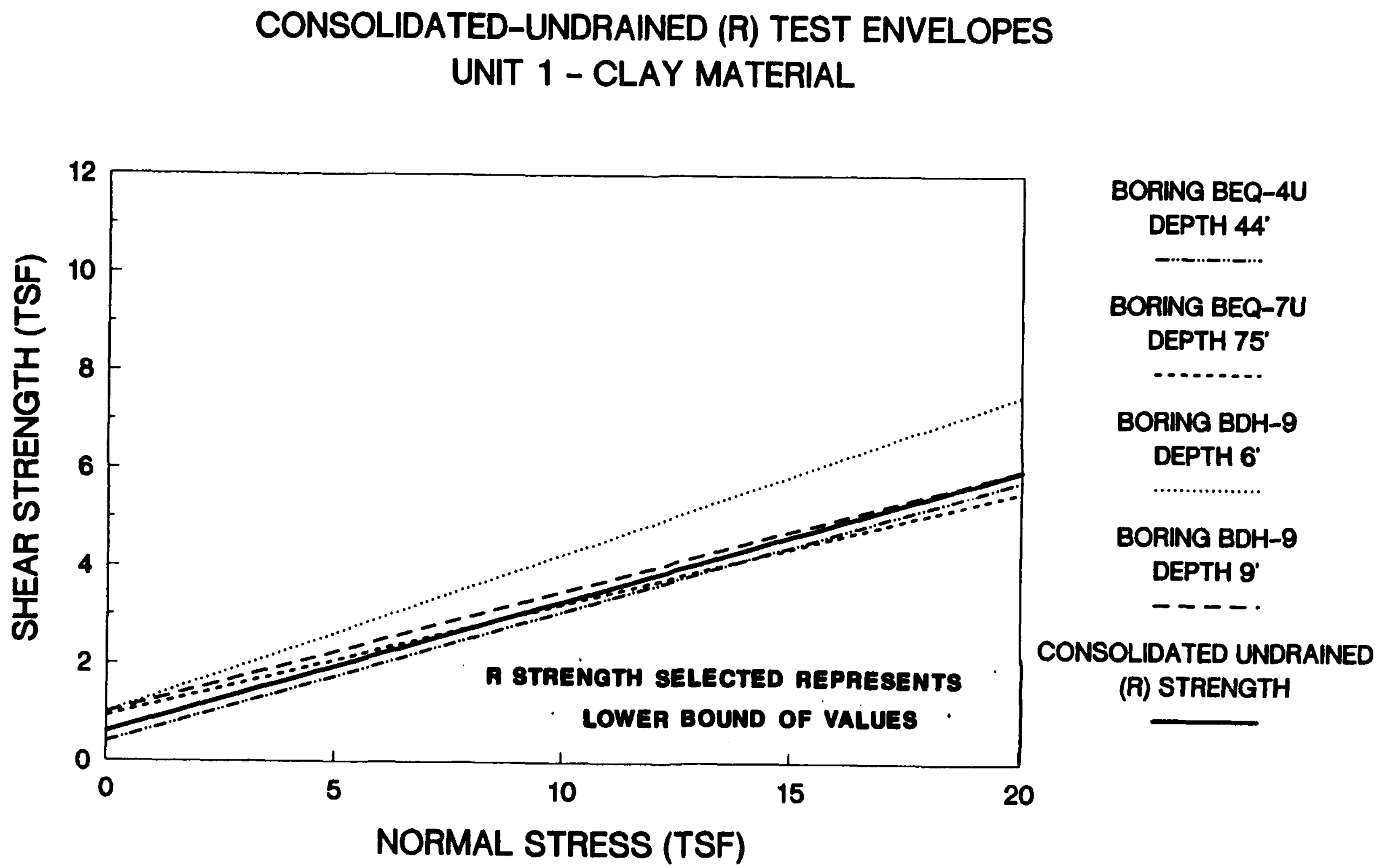


Figure 9. Consolidated - undrained (R) test envelopes for Unit 1 clay material.

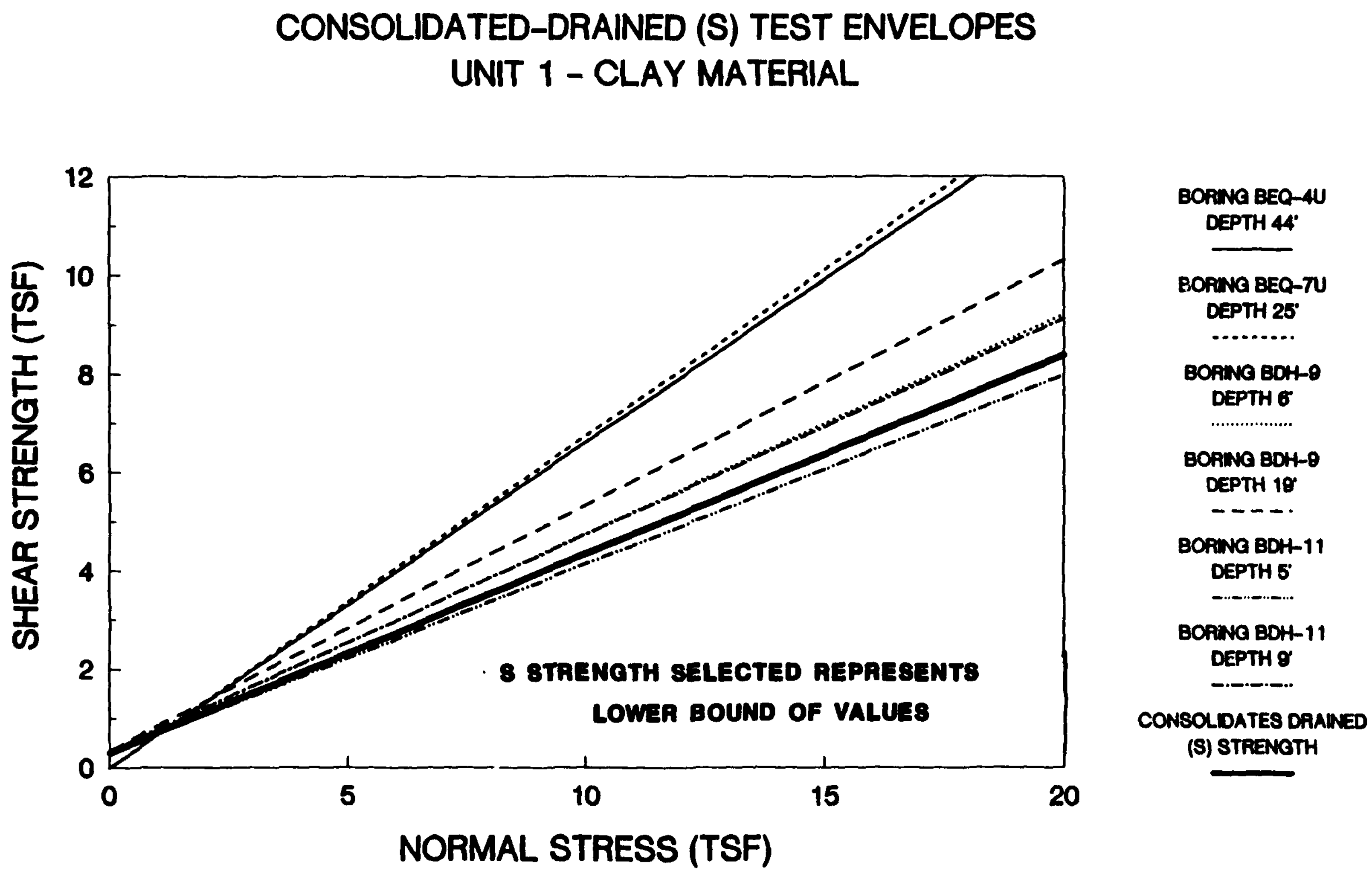


Figure 10. Consolidated - drained (S) test envelopes for Unit 1 clay material.

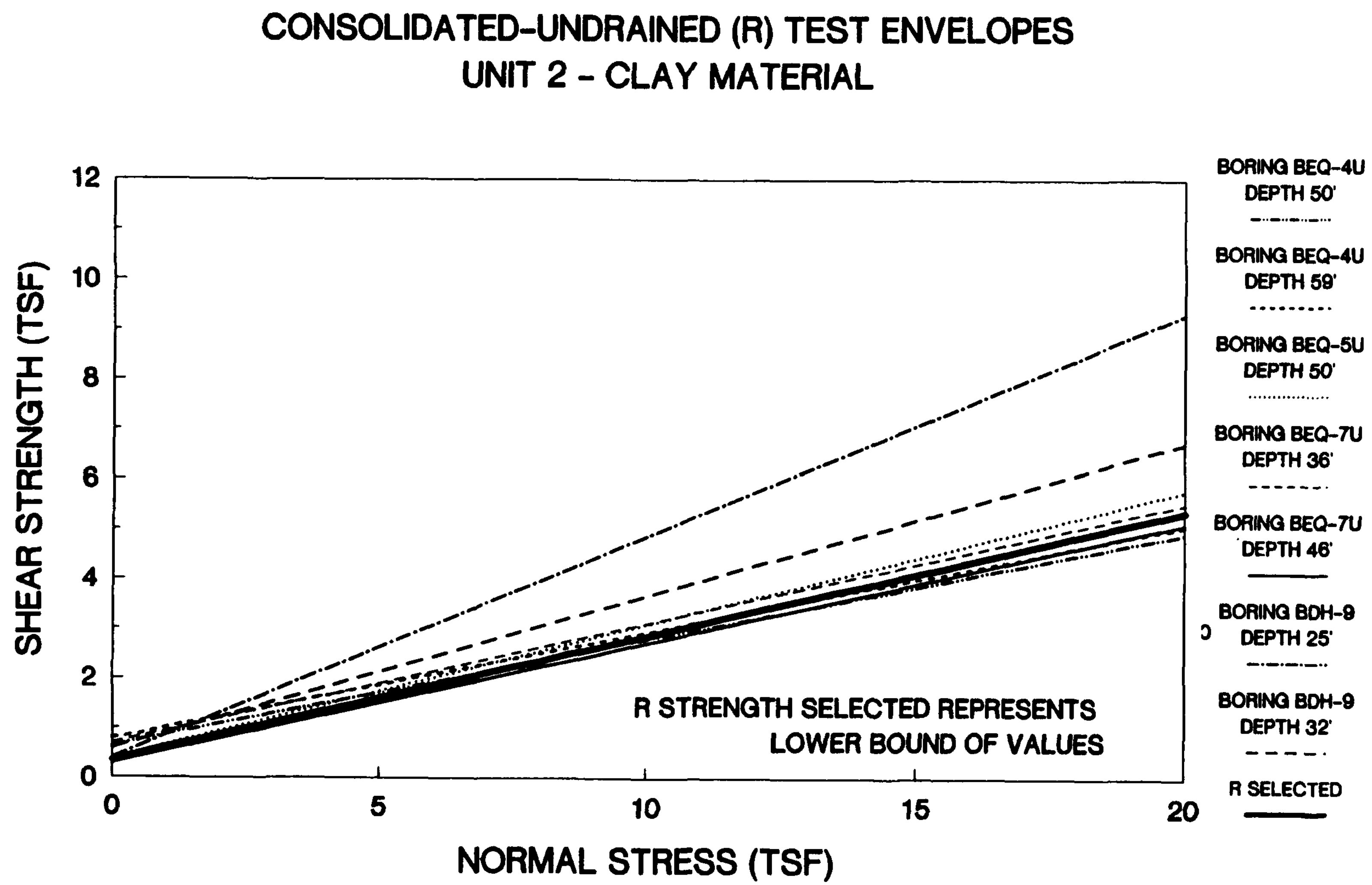


Figure 11. Consolidated - undrained (R) test envelopes for Unit 2 clay material.

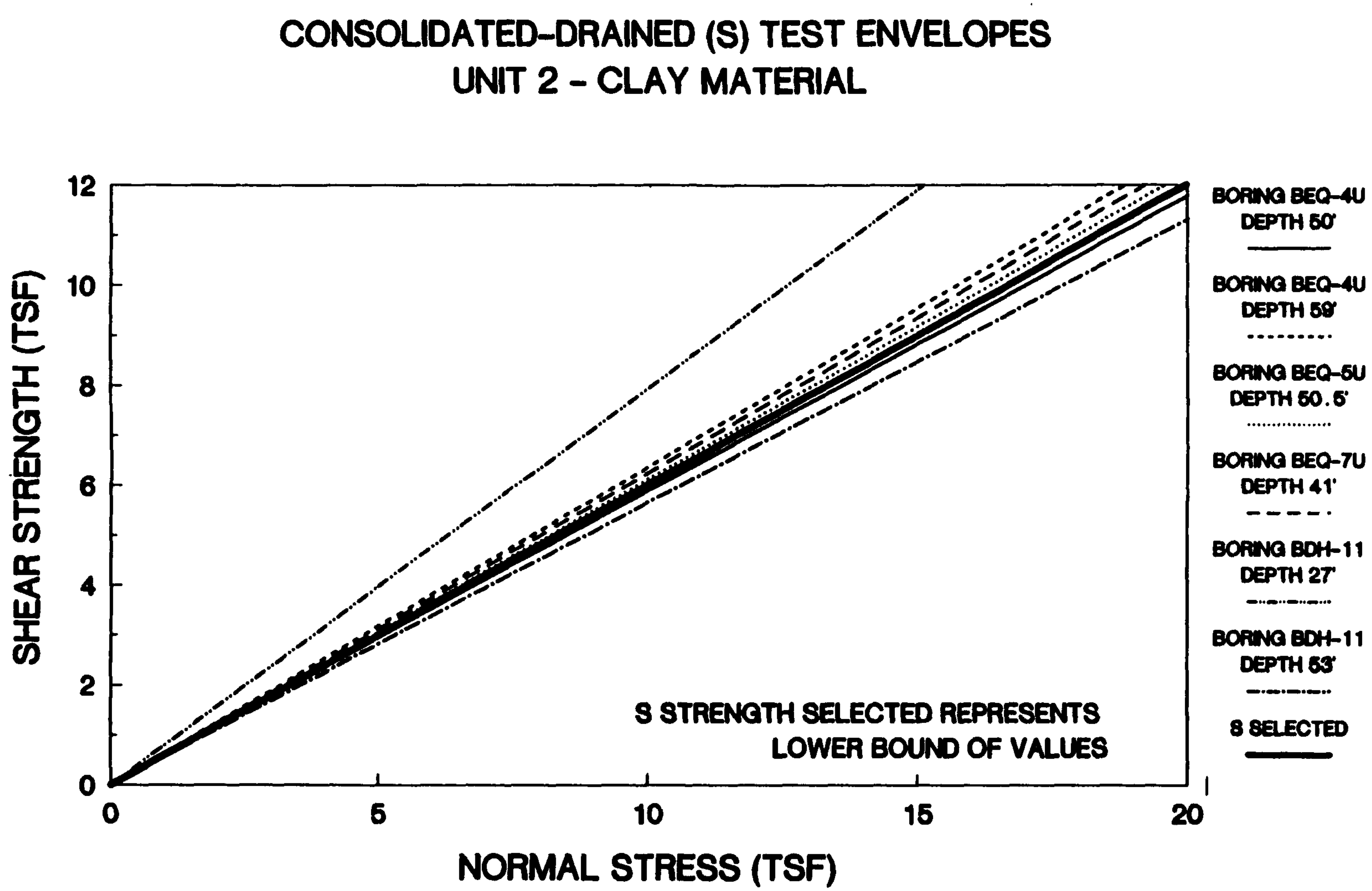


Figure 12. Consolidated - drained (S) test envelopes for Unit 2 clay material.

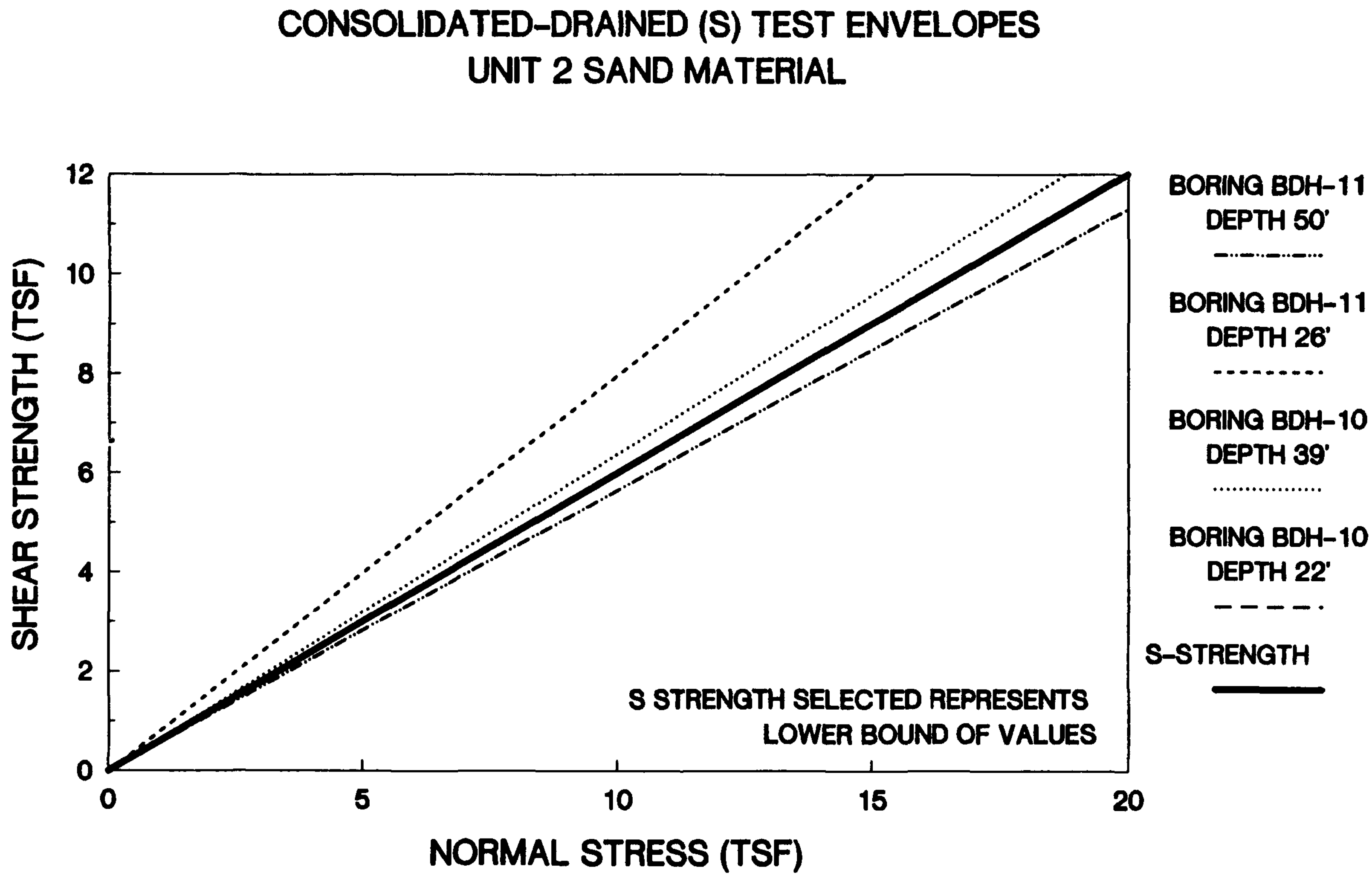


Figure 13. Consolidated - drained (S) test envelopes for Unit 2 sand material.

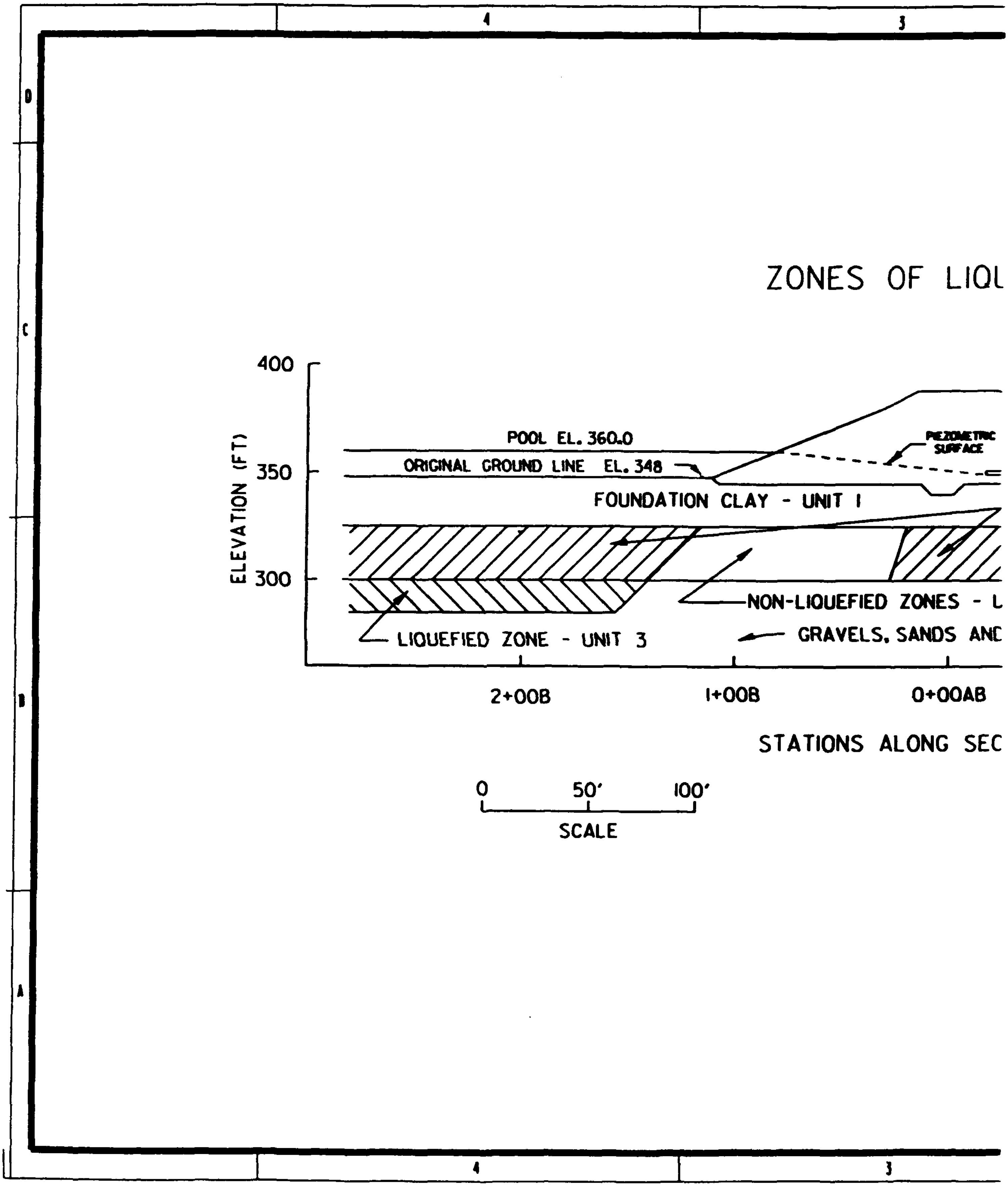
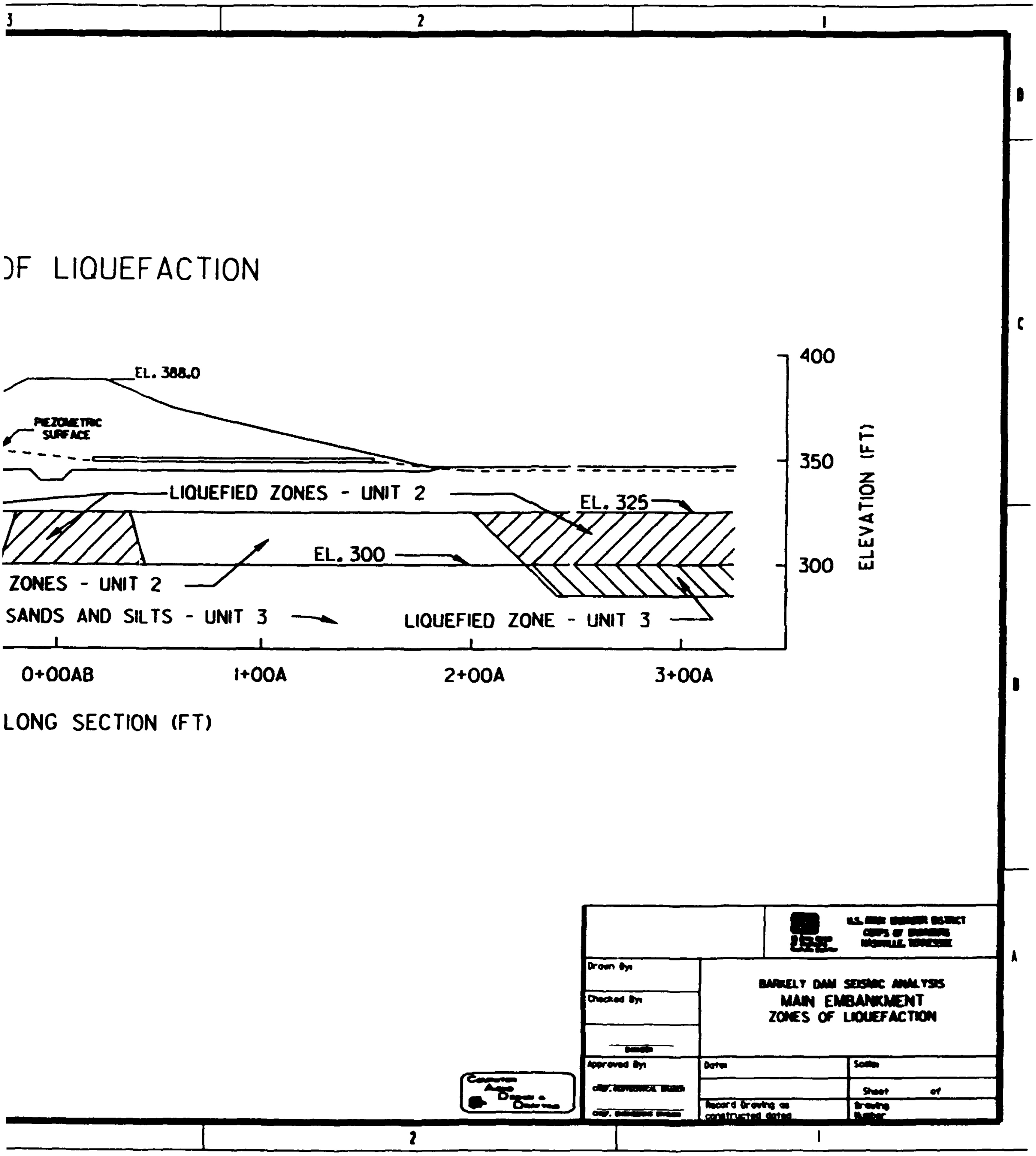


Figure 14. Main embankment



ankment - zones of liquefaction.

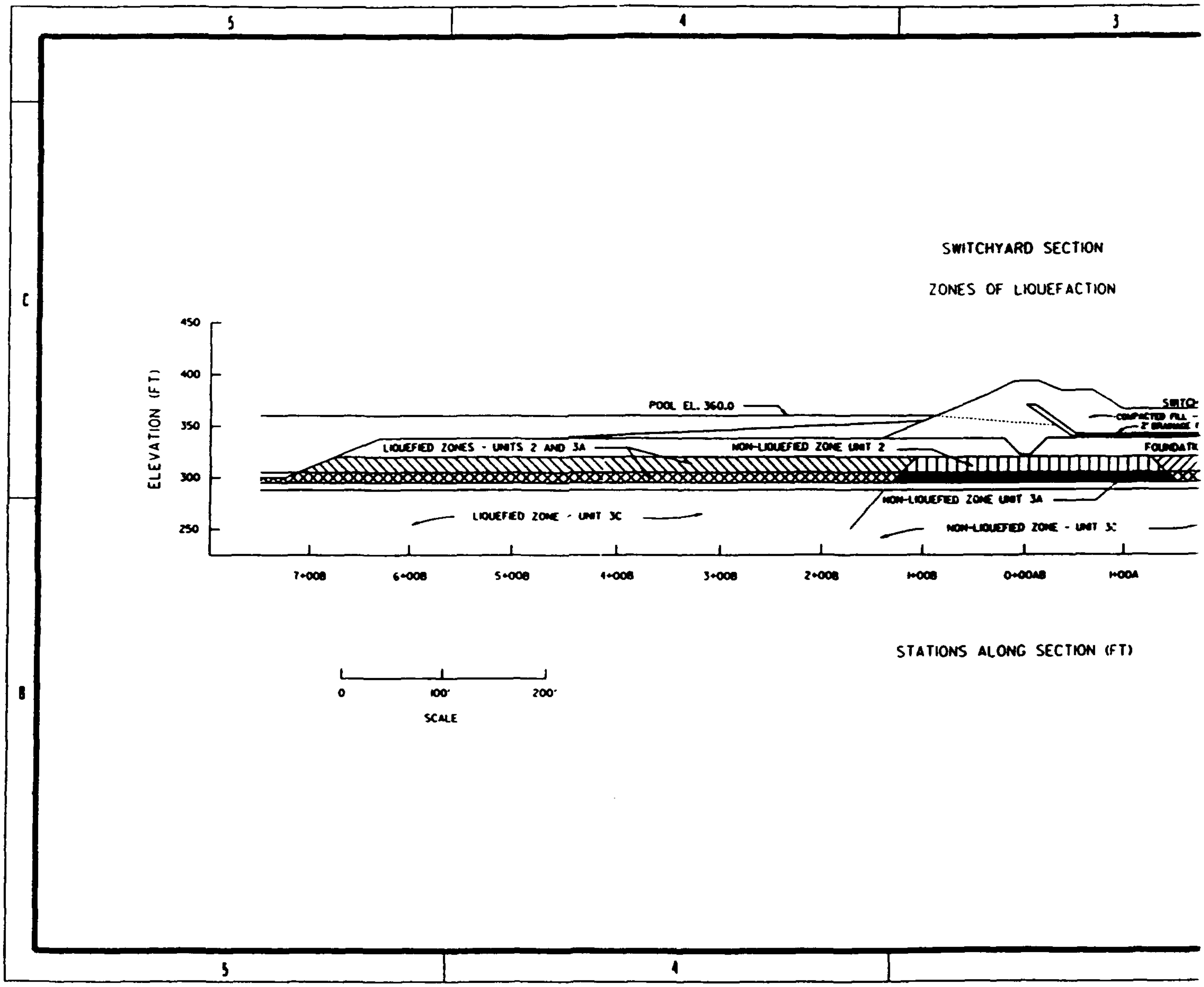
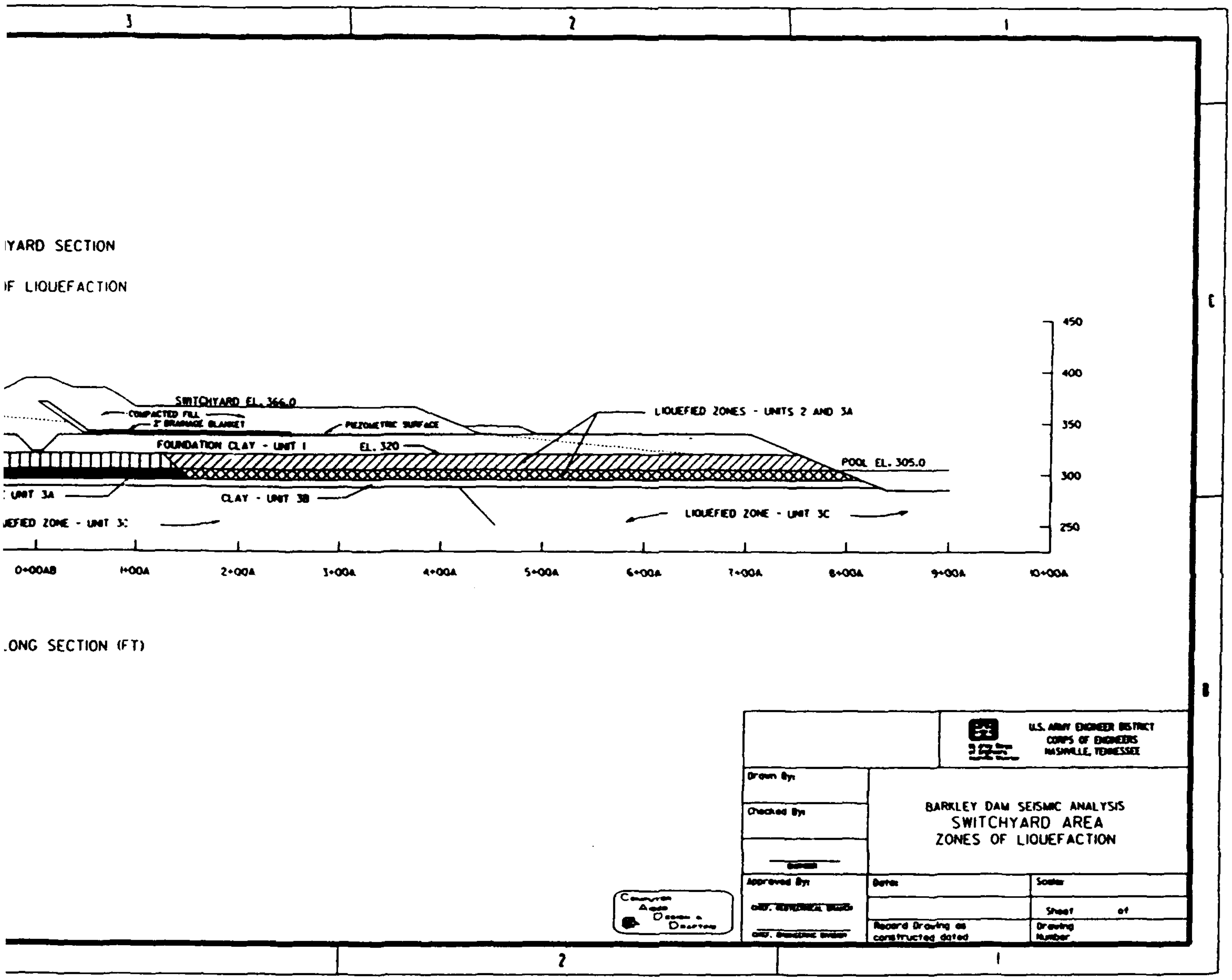


Figure 15. Zones of liquefaction f



iquefaction for the switchyard area.

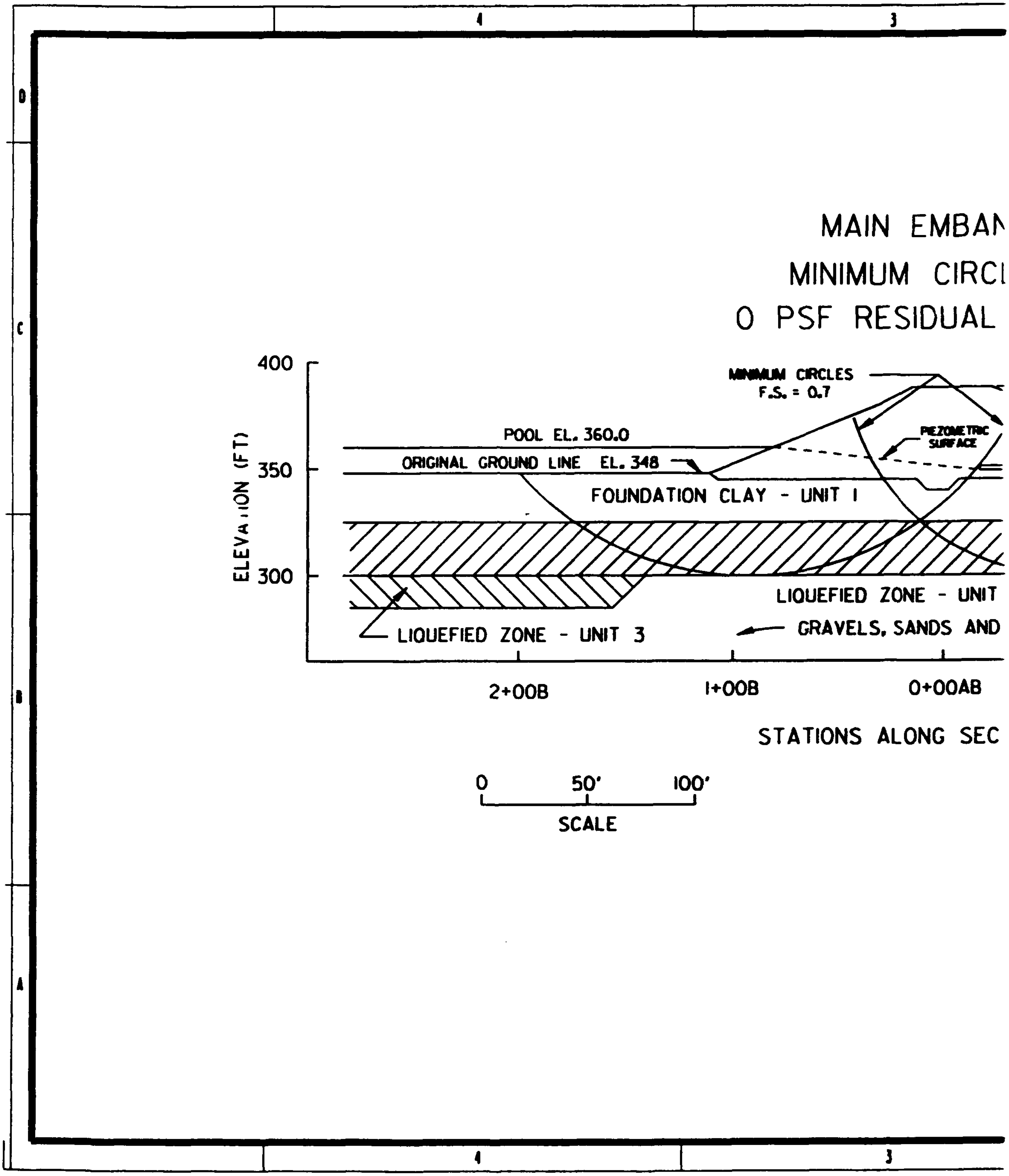
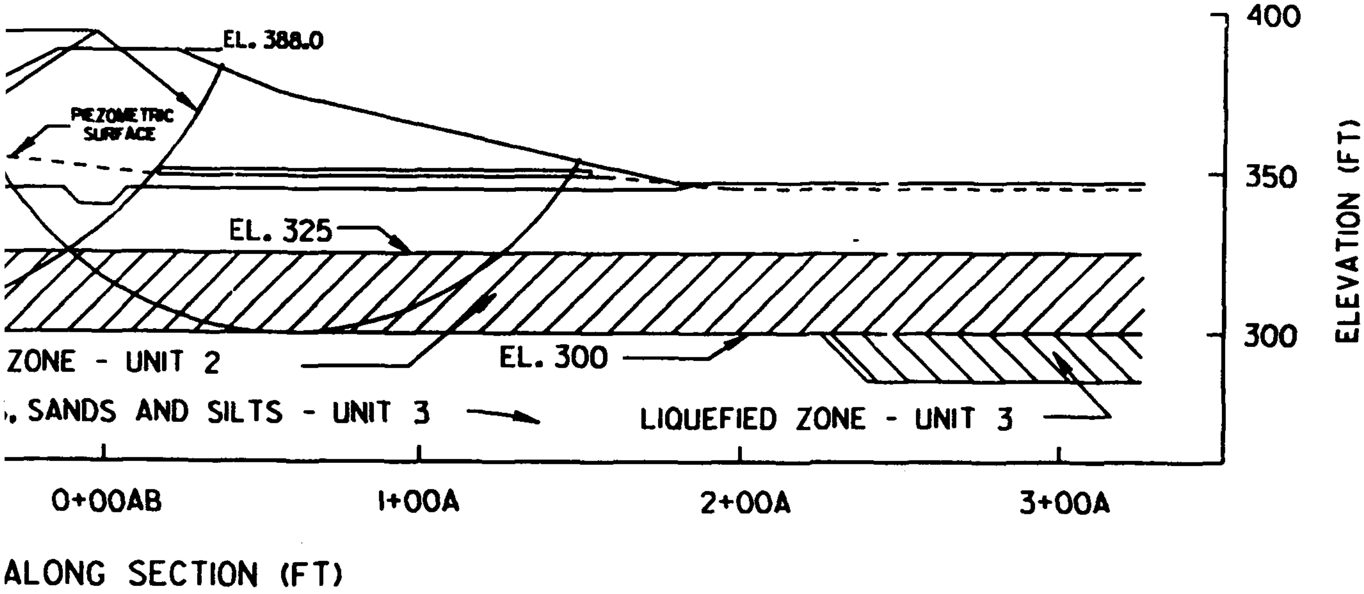


Figure 16. Minimum circles for 0 psf resid

N EMBANKMENT
JM CIRCLES FOR
ESIDUAL STRENGTH

STABILITY ANALYSIS PARAMETERS

MATERIAL	UNIT WEIGHT		C (PSF)	ϕ	% Ru
	γ_m	γ_{sat}			
COMPACTED FILL	126	128	800	18	---
UNIT 1 CLAY	115	125	960	12	---
LIQUEFIED ZONE - UNIT 2	122	126	0	0	---
UNIT 3 SANDS	126	128	0	35	50
LIQUEFIED ZONE - UNIT 3	126	128	0	0	---



U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NASHVILLE, TENNESSEE

BARKELY DAM SEISMIC ANALYSIS
MAIN EMBANKMENT
MINIMUM CIRCLES FOR
0 PSF RESIDUAL STRENGTH

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psf residual strength in liquefied zone of Unit 2.

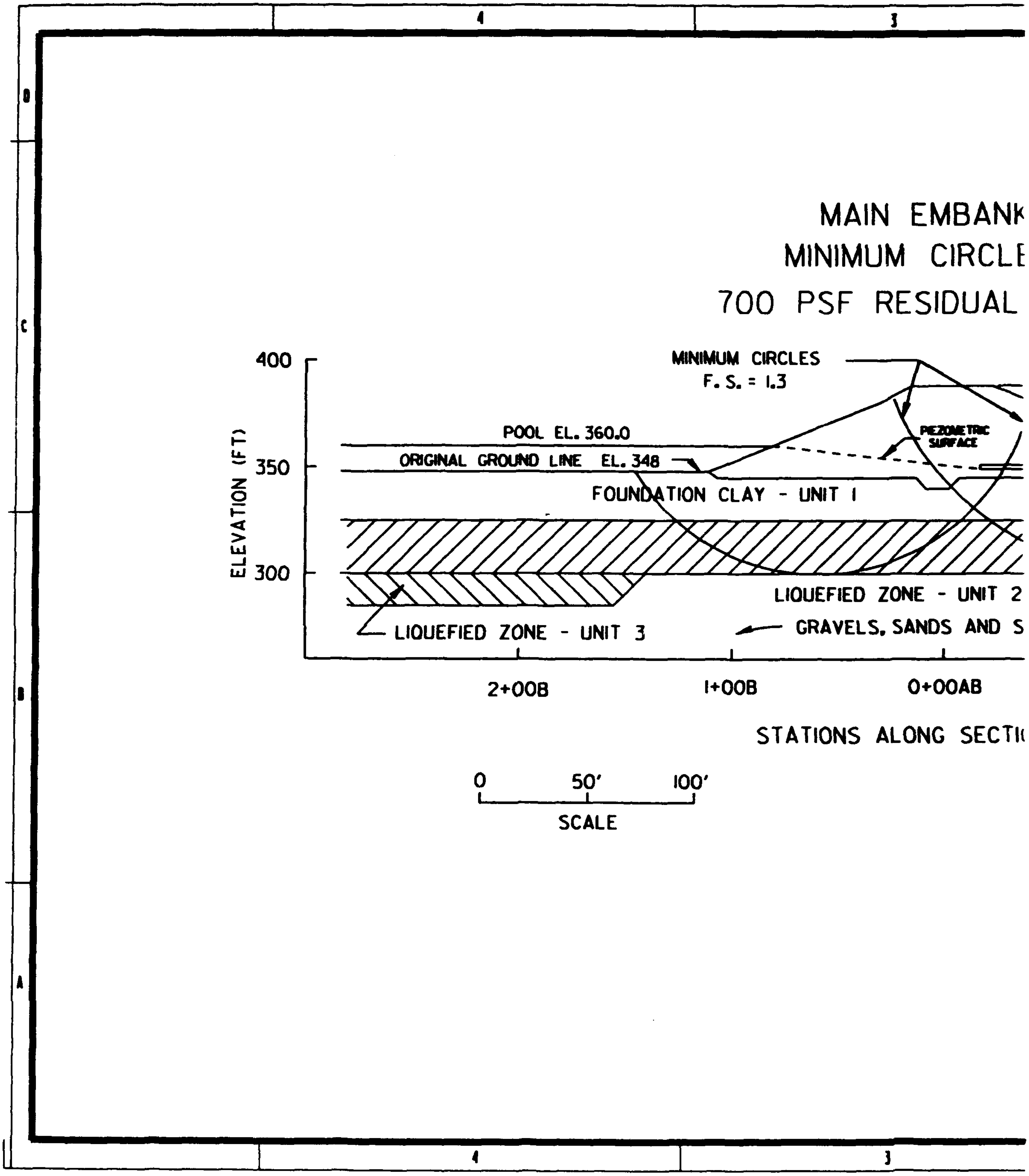
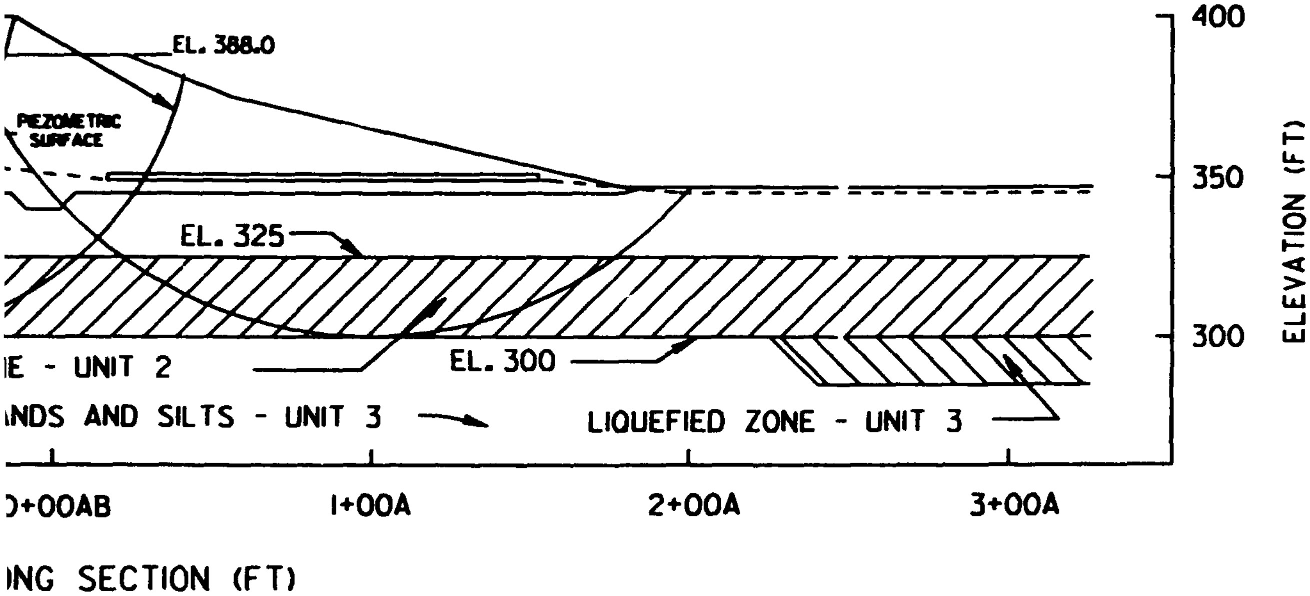


Figure 17. Minimum circles for 700 psf res

EMBANKMENT
CIRCLES FOR
SIDUAL STRENGTH

STABILITY ANALYSIS PARAMETERS

MATERIAL	UNIT WEIGHT		C (PSF)	ϕ	% Ru
	γ_m	γ_{sat}			
COMPACTED FILL	126	128	800	18	---
UNIT 1 CLAY	115	125	960	12	---
LIQUEFIED ZONE - UNIT 2	122	126	700	0	---
UNIT 3 SANDS	126	128	0	35	50
LIQUEFIED ZONE - UNIT 3	126	128	800	0	---



BARKELY DAM SEISMIC ANALYSIS
MAIN EMBANKMENT
MINIMUM CIRCLES FOR
700 PSF RESIDUAL STRENGTH

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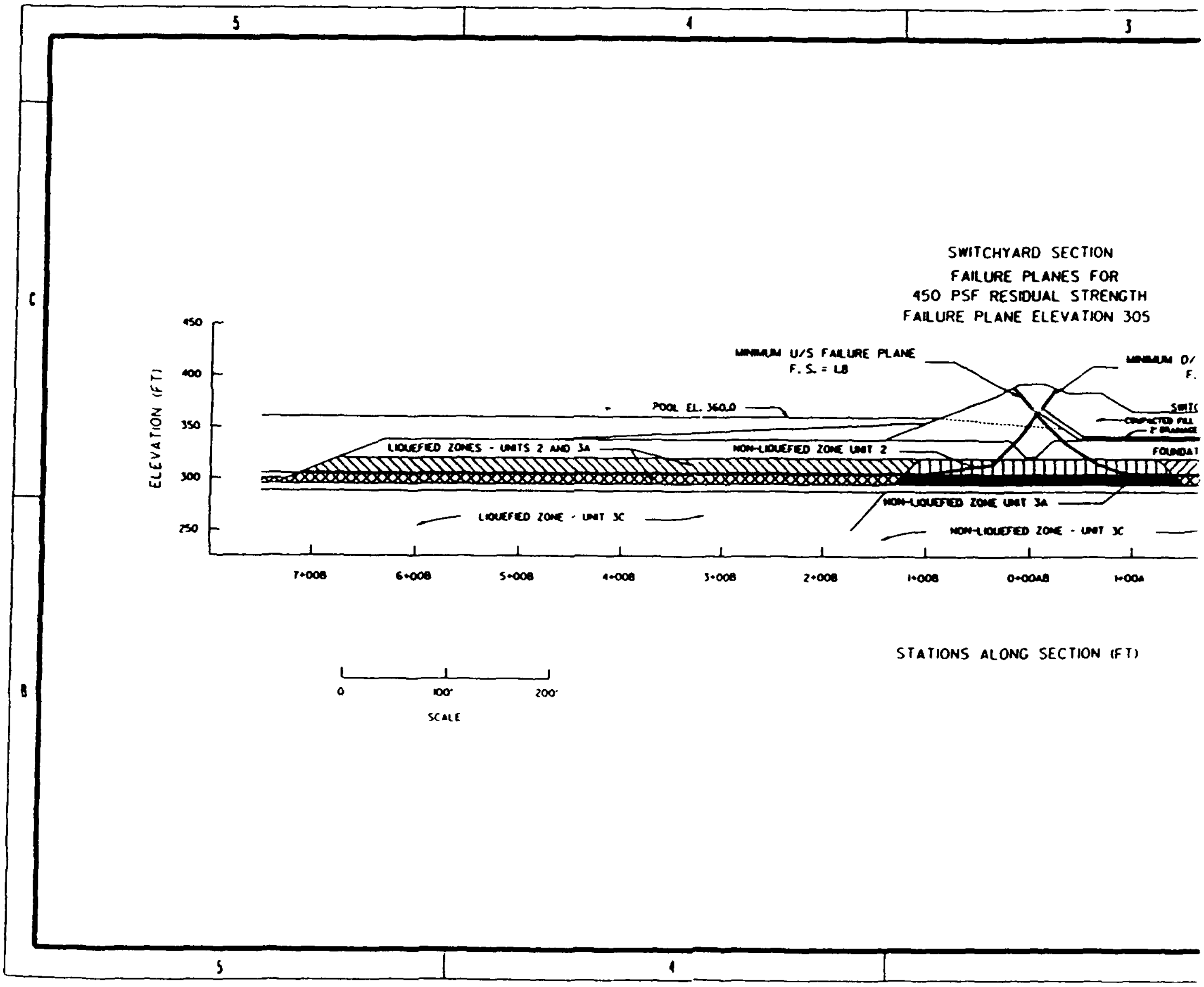


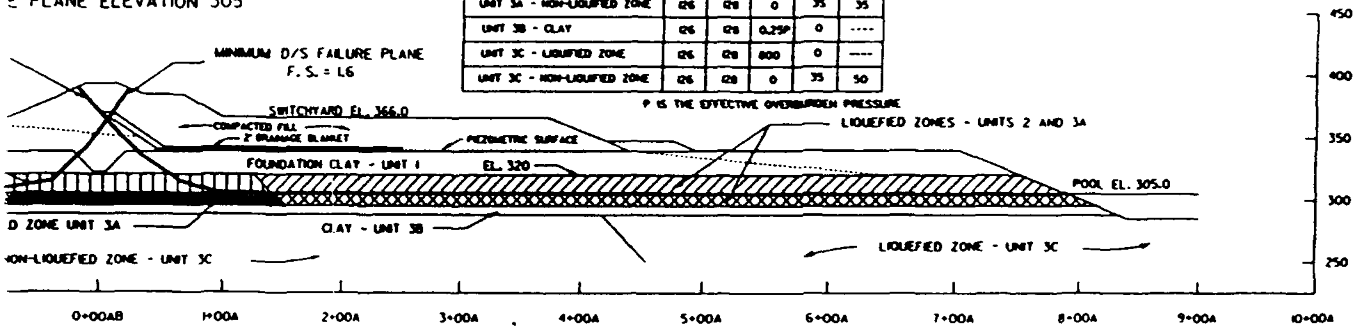
Figure 18. Minimum failure planes a
450 psf residual strength in liq

WITCHYARD SECTION
'AILURE PLANES FOR
'SF RESIDUAL STRENGTH
E PLANE ELEVATION 305

STABILITY ANALYSIS PARAMETERS

MATERIAL	UNIT WEIGHT		c (PSF)	φ	% Ru
	γ_m	γ_{sat}			
COMPACTED FILL	126	128	800	18	----
RANDOM FILL	126	128	320	6	----
UNIT 1 CLAY	115	125	960	12	----
UNIT 2 - LIQUEFIED ZONE	122	126	450	0	----
UNIT 2 - NON-LIQUEFIED ZONE	122	126	0.25P	0	---
UNIT 3A - LIQUIFIED ZONE	126	128	800	0	----
UNIT 3A - NON-LIQUIFIED ZONE	126	128	0	35	35
UNIT 3B - CLAY	126	128	0.25P	0	----
UNIT 3C - LIQUIFIED ZONE	126	128	800	0	----
UNIT 3C - NON-LIQUIFIED ZONE	126	128	0	35	50

P IS THE EFFECTIVE OVERBURDEN PRESSURE



NS ALONG SECTION (FT)

U.S. ARMY ENGINEER DISTRICT
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NASHVILLE, TENNESSEE

Drawn By:
Checked By:
Approved By:

BARKLEY DAM SEISMIC ANALYSIS
SWITCHYARD AREA
450 PSF RESIDUAL STRENGTH
FAILURE PLANE ELEVATION 305

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Record Drawing as constructed dated
Drawing Number

Computer Aided Design & Drafting

failure planes at elevation 305 feet with
strength in liquefied zone of Unit 2.

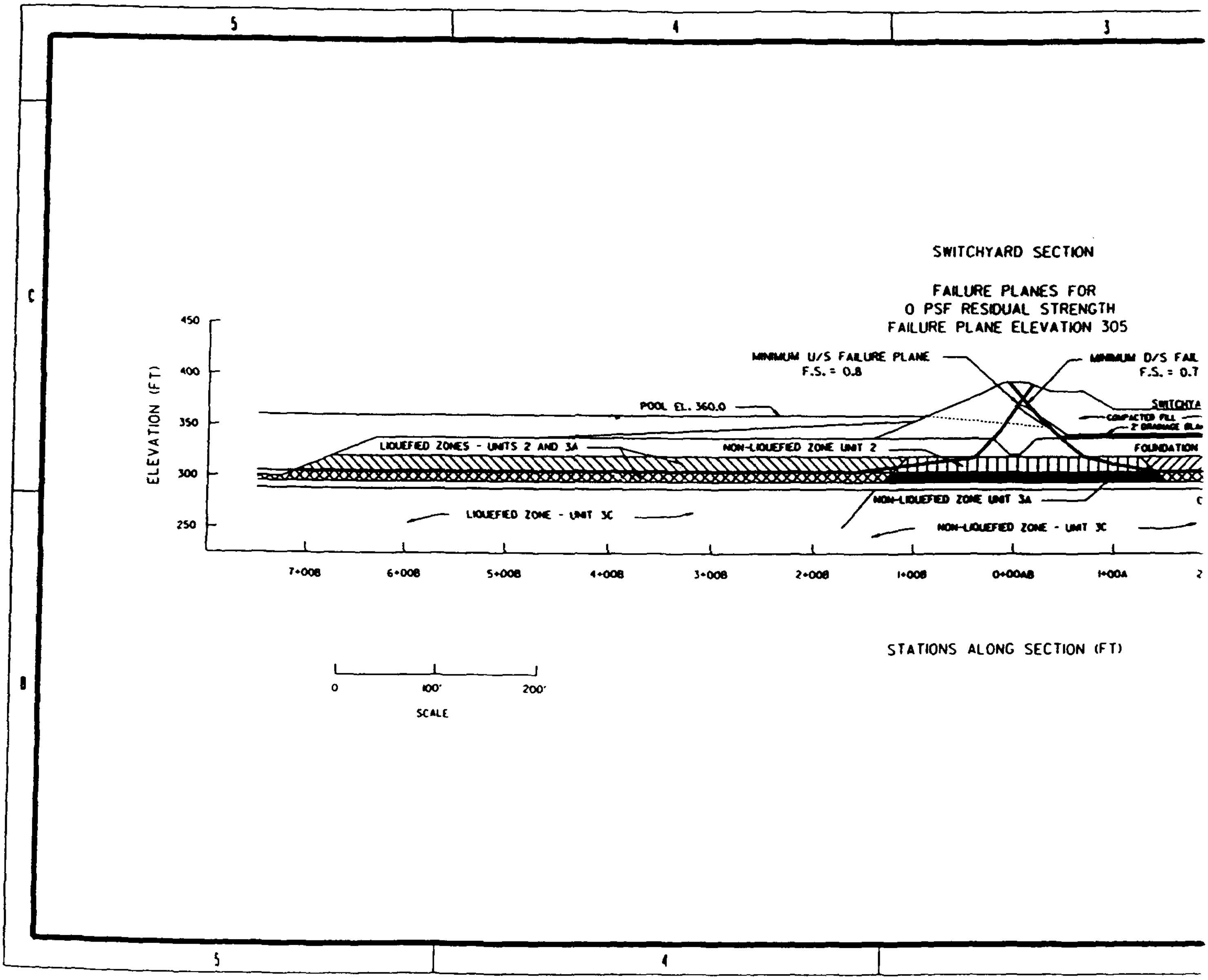


Figure 19. Minimum failure planes at e
0 psf residual strength in liquefi

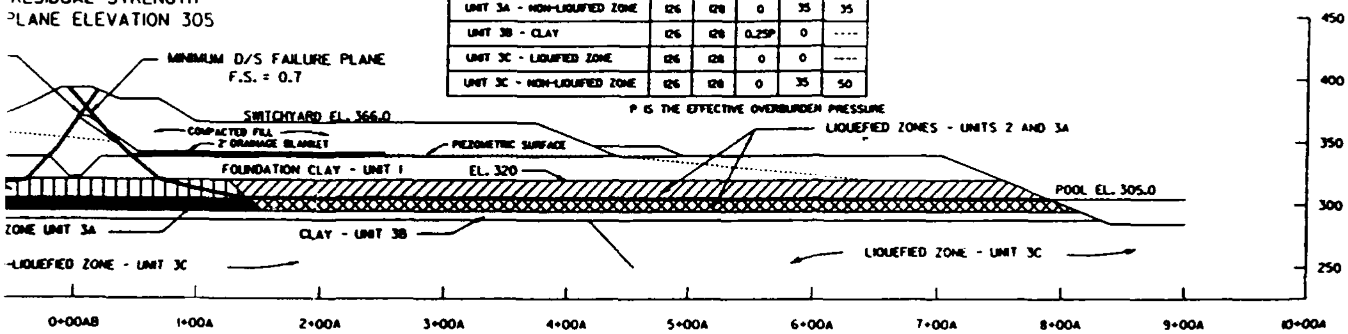
STABILITY ANALYSIS PARAMETERS

MATERIAL	UNIT WEIGHT γ_m	UNIT WEIGHT γ_{sat}	c (PSF)	φ	% Ru
COMPACTED FILL	126	128	800	[illegible]	----
RANDOM FILL	126	128	320	6	----
UNIT 1 CLAY	115	125	960	12	----
UNIT 2 - LIQUEFIED ZONE	122	126	0	0	----
UNIT 2 - NON-LIQUEFIED ZONE	122	126	0.25P	0	---
UNIT 3A - LIQUIFIED ZONE	126	128	0	0	----
UNIT 3A - NON-LIQUIFIED ZONE	126	128	0	35	35
UNIT 3B - CLAY	126	128	0.25P	0	----
UNIT 3C - LIQUIFIED ZONE	126	128	0	0	----
UNIT 3C - NON-LIQUIFIED ZONE	126	128	0	35	50

P IS THE EFFECTIVE OVERBURDEN PRESSURE

:CHYARD SECTION

.URE PLANES FOR
RESIDUAL STRENGTH
PLANE ELEVATION 305



ALONG SECTION (FT)

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NASHVILLE, TENNESSEE

Drawn By:	BARKLEY DAM SEISMIC ANALYSIS SWITCHYARD AREA 0 PSF RESIDUAL STRENGTH FAILURE PLANE ELEVATION 305
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Approved By:	Date: / Scale:
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	Record Drawing as constructed dated / Drawing Number

Computer Aided Design & Drafting

.lure planes at elevation 305 feet with
'ength in liquefied zone of Unit 2.

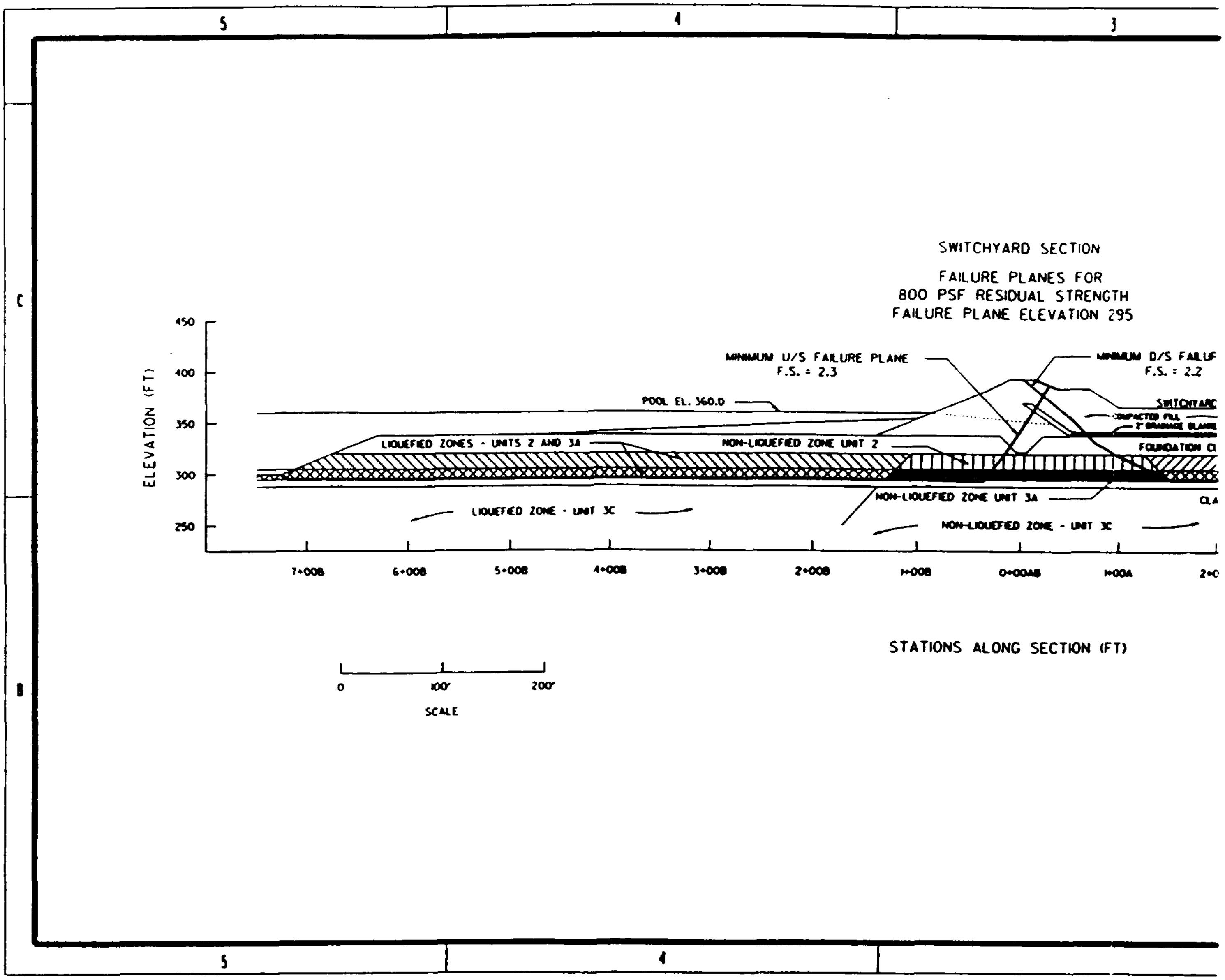


Figure 20. Minimum failure planes at
800 psf residual strength in lique

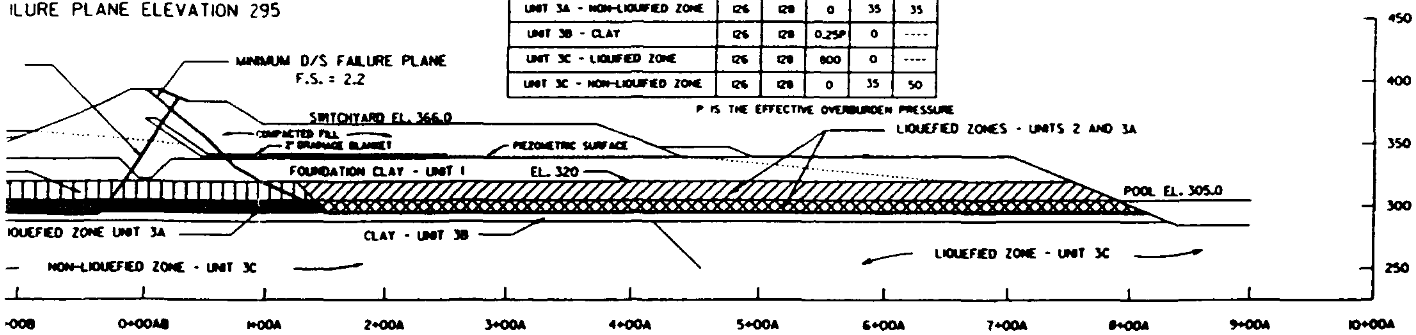
SWITCHYARD SECTION

FAILURE PLANES FOR
)0 PSF RESIDUAL STRENGTH
ILURE PLANE ELEVATION 295

STABILITY ANALYSIS PARAMETERS

MATERIAL	UNIT WEIGHT		c	ϕ	% Ru
	γ_m	γ_{sat}	(PSF)		
COMPACTED FILL	126	128	800	18	----
RANDOM FILL	126	128	320	6	----
UNIT 1 CLAY	115	125	960	12	----
UNIT 2 - LIQUEFIED ZONE	122	126	450	0	----
UNIT 2 - NON-LIQUEFIED ZONE	122	126	0.25P	0	---
UNIT 3A - LIQUIFIED ZONE	126	128	800	0	----
UNIT 3A - NON-LIQUIFIED ZONE	126	128	0	35	35
UNIT 3B - CLAY	126	128	0.25P	0	----
UNIT 3C - LIQUIFIED ZONE	126	128	800	0	----
UNIT 3C - NON-LIQUIFIED ZONE	126	128	0	35	50

P IS THE EFFECTIVE OVERBURDEN PRESSURE



ATIONS ALONG SECTION (FT)

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NASHVILLE, TENNESSEE

Drawn By:

Checked By:

Approved By:

BARKLEY DAM SEISMIC ANALYSIS
SWITCHYARD AREA
800 PSF RESIDUAL STRENGTH
FAILURE PLANE ELEVATION 295

Date:

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Drawing Number

Computer Aided Design & Drafting

ıum failure planes at elevation 295 feet with
ıal strength in liquefied zone of Unit 3A.

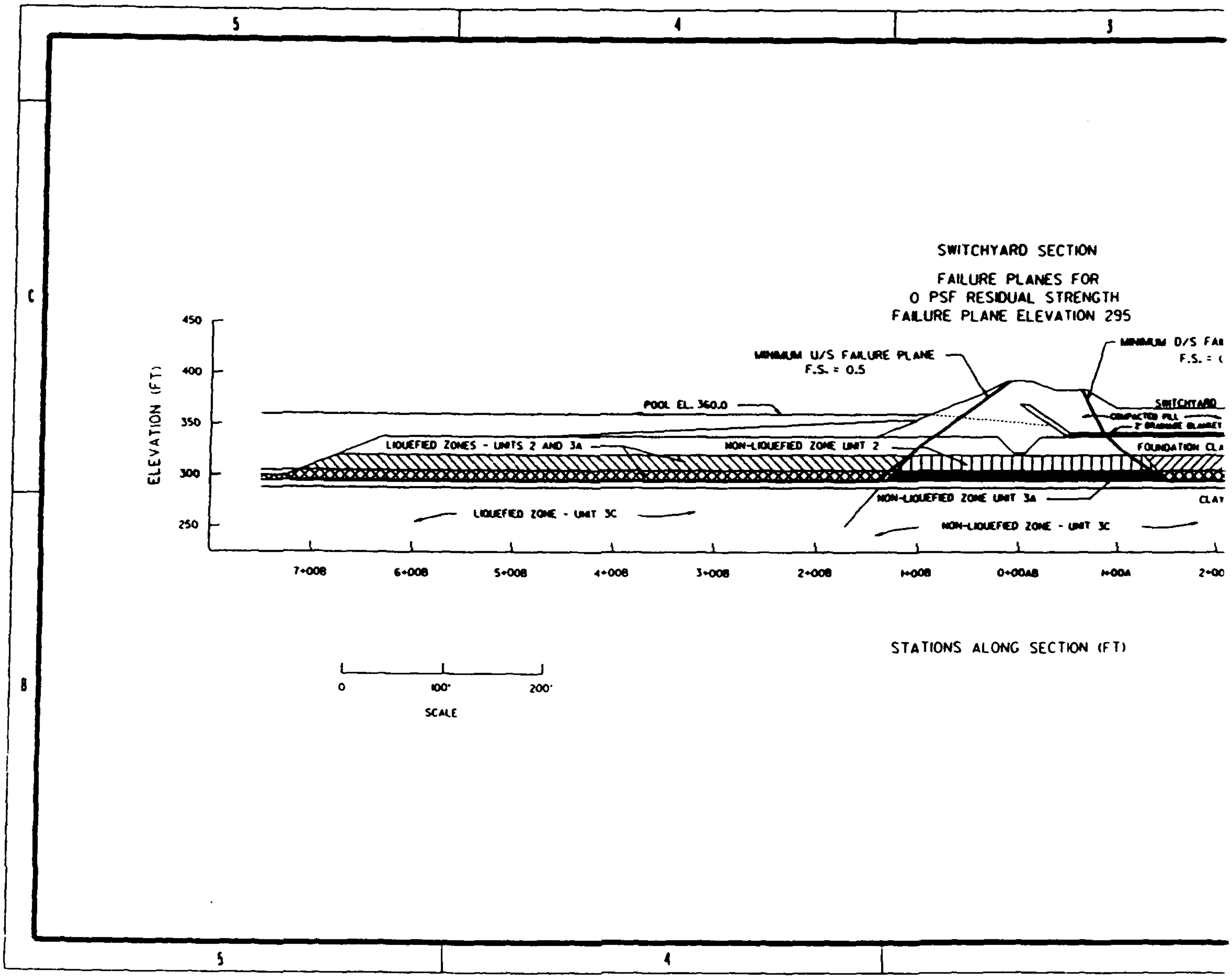


Figure 21. Minimum failure planes at ε
0 psf residual strength ir

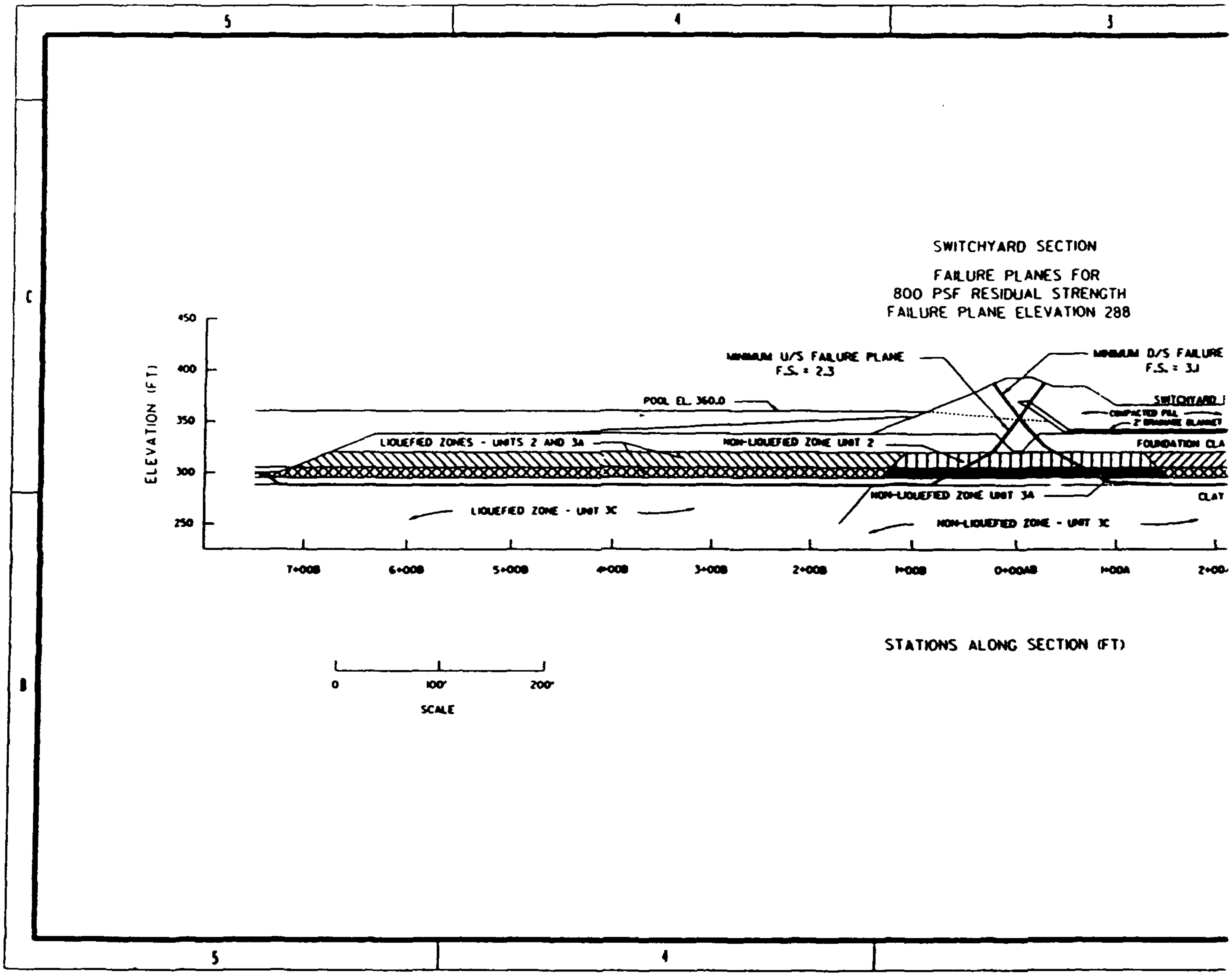


Figure 22. Minimum failure planes
800 psf residual strength in liq

3	2	1

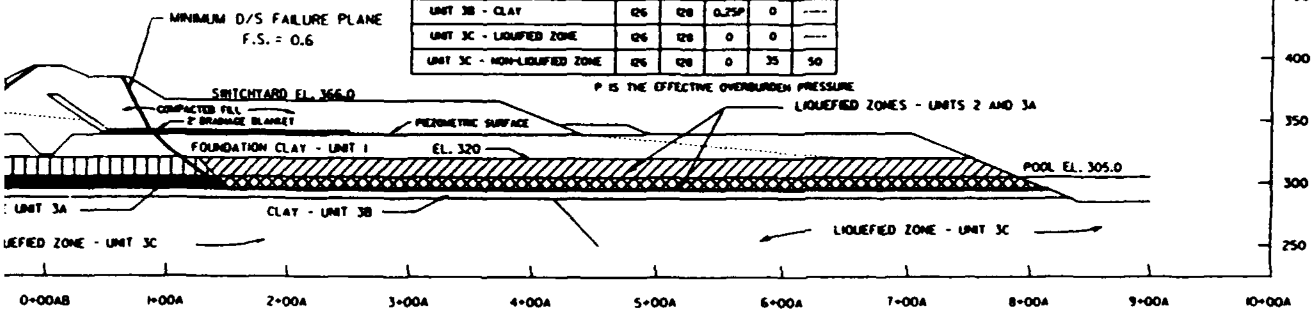
STABILITY ANALYSIS PARAMETERS

MATERIAL	UNIT WEIGHT γ_m	UNIT WEIGHT γ_{sat}	c (PSF)	ϕ	% Ru
COMPACTED FILL	126	128	800	18	----
RANDOM FILL	126	128	320	6	----
UNIT 1 CLAY	115	125	960	12	----
UNIT 2 - LIQUEFIED ZONE	122	126	0	0	----
UNIT 2 - NON-LIQUEFIED ZONE	122	126	0.25P	0	---
UNIT 3A - LIQUIFIED ZONE	126	128	0	0	----
UNIT 3A - NON-LIQUIFIED ZONE	126	128	0	35	35
UNIT 3B - CLAY	126	128	0.25P	0	----
UNIT 3C - LIQUIFIED ZONE	126	128	0	0	----
UNIT 3C - NON-LIQUIFIED ZONE	126	128	0	35	50

P IS THE EFFECTIVE OVERBURDEN PRESSURE

IYARD SECTION

:E PLANES FOR
SIDUAL STRENGTH
INE ELEVATION 295



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U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NASHVILLE, TENNESSEE

Drawn By:

Checked By:

Approved By:

BARKLEY DAM SEISMIC ANALYSIS
SWITCHYARD AREA
0 PSF RESIDUAL STRENGTH
FAILURE PLANE ELEVATION 295

Date:

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Computer Aided Design & Drafting

2	1

lure planes at elevation 295 feet with
dual strength in Unit 3A.

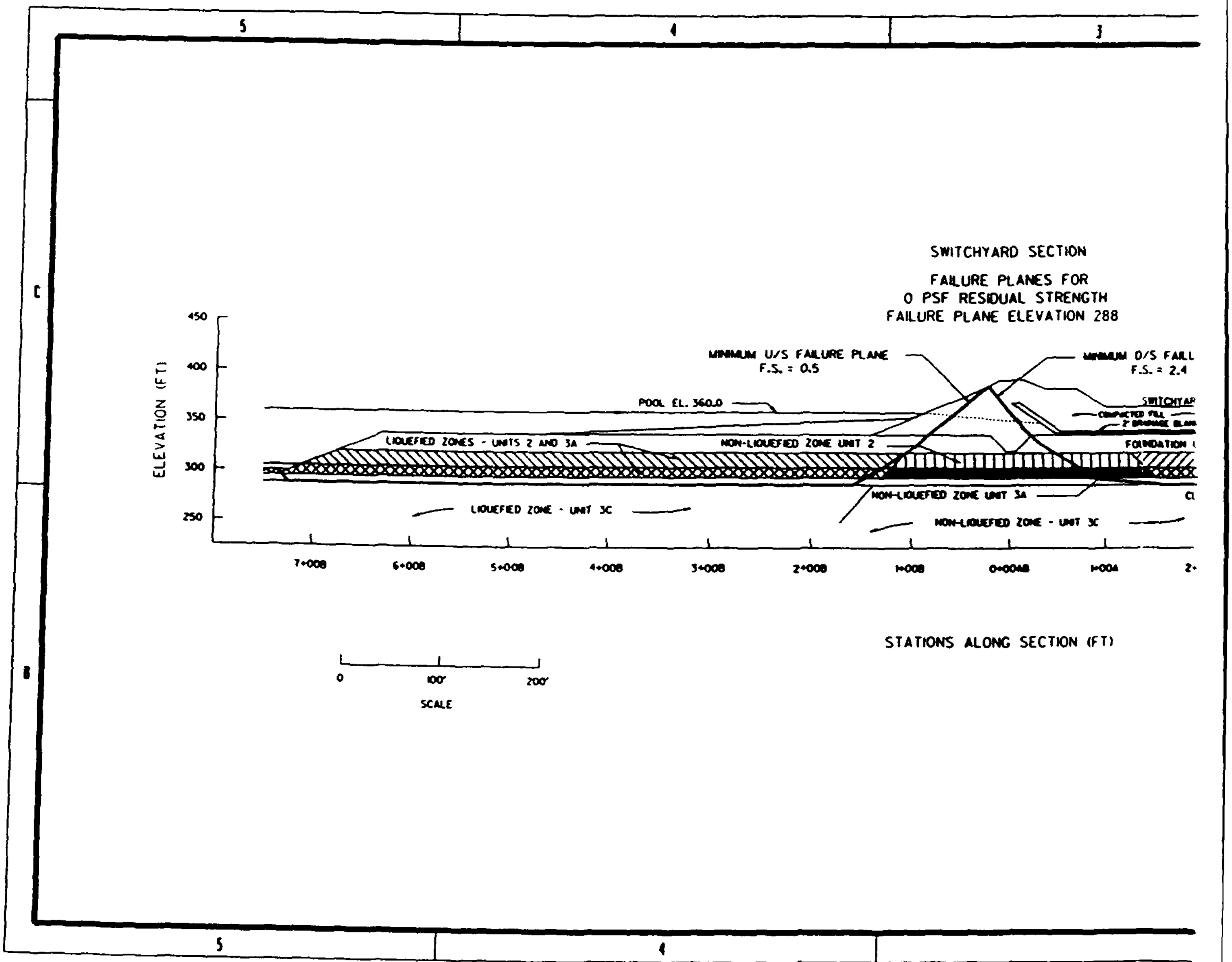


Figure 23. Minimum failure planes at
residual strength in liquef

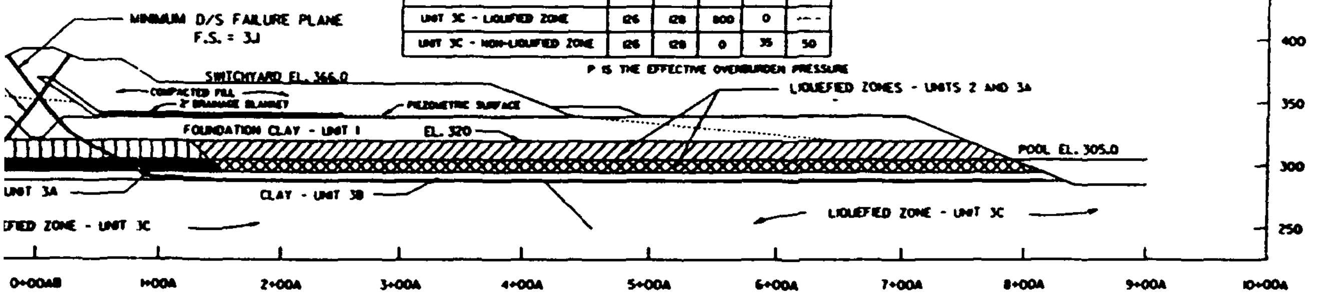
STABILITY ANALYSIS PARAMETERS

MATERIAL	UNIT WEIGHT γ_m	UNIT WEIGHT γ_{sat}	c (PSF)	ϕ	% Ru
COMPACTED FILL	126	128	800	18	----
RANDOM FILL	126	128	320	6	----
UNIT 1 CLAY	115	125	960	12	----
UNIT 2 - LIQUEFIED ZONE	122	126	450	0	----
UNIT 2 - NON-LIQUEFIED ZONE	122	126	0.25P	0	---
UNIT 3A - LIQUIFIED ZONE	126	128	800	0	----
UNIT 3A - NON-LIQUIFIED ZONE	126	128	0	35	35
UNIT 3B - CLAY	126	128	0.25P	0	----
UNIT 3C - LIQUIFIED ZONE	126	128	800	0	----
UNIT 3C - NON-LIQUIFIED ZONE	126	128	0	35	50

P IS THE EFFECTIVE OVERBURDEN PRESSURE

'ARD SECTION

: PLANES FOR
SIDUAL STRENGTH
IE ELEVATION 288



ONG SECTION (FT)

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NASHVILLE, TENNESSEE

Drawn By:

Checked By:

App:

BARKLEY DAM SEISMIC ANALYSIS
SWITCHYARD AREA
800 PSF RESIDUAL STRENGTH
FAILURE PLANE ELEVATION 288

Date:

Scale:

Sheet of

Record Drawing as constructed dated

Drawing Number

Computer Aided Design & Drafting

failure planes at elevation 288 feet with
strength in liquefied zone of Unit 3C.

Waterways Experiment Station Cataloging-in-Publication Data

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The purpose of this study was to determine if planning should proceed to feasibility. The conclusion of the report indicates that raising the height of the existing levee built by the SCS in 1980, along with channel clearing, is an economically feasible plan. While we don't at this time have a sponsor, we are working toward a joint effort with the SCS to perform additional studies and construction of a project. This would be accomplished at 100 percent Federal cost.

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SECTION 205 RECONNAISSANCE REPORT

CHATTOOGA RIVER
TRION, GEORGIA

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SECTION 205
RECONNAISSANCE REPORT

CHATTOOGA RIVER
TRION, GEORGIA

AUTHORITY AND BACKGROUND

This reconnaissance report was prepared and submitted under the authority contained in Section 205 of the Flood Control Act of 1948, as amended. It is in response to an April 16, 1990, request by the Mayor of Trion, Georgia, for the Corps of Engineers to perform a flood control study. A copy of Mayor Williams' letter is included in Appendix B. This request came after severe flooding occurred in Trion during February 1990, when the Chattooga River forced evacuation of an estimated 700 people and devastated the community. This flood was estimated to be a 70-year flood event and is pictured on the cover of this report.

PURPOSE AND SCOPE

The studies presented in this report deal with the flooding problems caused by the Chattooga River in the town of Trion. The purpose of this report is to identify problems and opportunities and determine whether the planning should proceed to feasibility, based on a preliminary appraisal of the Federal interest, cost, benefits, and environmental impacts of the potential solutions.

DESCRIPTION OF STUDY AREA

Physical setting. The town of Trion is located on the banks of the Chattooga River in northern Chattooga County in northwest Georgia. Chattooga County is situated in the Coosa Valley and Ridge Physiographic Province whose terrain is characterized by hilly ridge areas and lowlands with elevations ranging from 600 to 2000 feet National Geodetic Vertical Datum of 1929(NGVD). The major soil groupings in the county are the Clarksville and Decatur groups. A county map is shown on plate 5.

The Chattooga River enters Trion from the north and then meanders easterly through the center of town. Cane Creek, Spring Branch, and Chappel Creek flow south through town to the Chattooga River and Trion Branch flows north into the river.

Existing Projects. Partial protection from flooding is provided to the Frogtown area of the community by an earth levee, which was constructed by the U. S. Soil Conservation Service in 1980, under the Authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress, 68 Stat. 666), as amended. The

levee is about 2400 feet in length and extends from Central Avenue to First Street as shown on plate 3. The levee was built to 659.0 feet NGVD, which was the elevation for the flood of record at the time the project was designed. Allowing for 2 feet of freeboard, the levee currently provides to about the 10-year level of protection

Socioeconomic Profile. In the 1980 U.S. Census Chattooga County had a total population of 21,856 and the town of Trion had a total population of 1,732. Chattooga County experienced a 3.0 percent increase in population from 1970 to 1980. The Bureau of Economic Analysis estimates the population of Chattooga County to total 22,194 people in 1990 and expand to a population of 22,281 by the year 1993, which is the estimated project completion date. The racial composition of the 1980 population in Trion is approximately 98 percent white and 2 percent black. Approximately 60 percent of the population was between the age of 18 and 64 and the median age was 44.

The floodplain has 169 structures valued at $235,264,600 in September 1990. As a percentage of the dollar value of the floodplain, 97 percent is public or industrial, while only 2 percent is residential and 1 percent is commercial. A detailed inventory of the property value by category is presented in Table 5.

PROBLEMS, NEEDS AND OPPORTUNITIES

Problems. Low lying areas of Trion are periodically flooded when the Chattooga River overflows its banks. Significant flooding has occurred in January 1946, November 1948, January 1949, March 1951, March 1952, March 1966 and February 1990. The 1990 flood was the flood of record and caused significant damages to industrial, public and residential property. This flood, which was estimated to be a 70-year flood event, caused over $2.3 million in damages, and forced the evacuation of about 700 people.

Views and desires of local interests. Local interests, as represented by public officials and other interested citizens, desire a levee around flood prone areas of the community. However, these interests want to insure that the project design allows for drainage of local surface runoff. Regal Mill representatives thought that damages to the mill and disruption to operations would be substantial if a floodwall or similar structure did not allow for the surface runoff to drain from the mill yard. The Regal Mill is located on the north bank of the Chattooga River and is the principal employer in the town.

WITHOUT-PROJECT CONDITIONS

No future growth is anticipated in the floodplain since there is adequate room out of the floodplain for future development. Futhermore, the town participates in the Federal Flood Insurance program which zones and regulates floodplain development. Therefore, the existing condition damages are expected to remain an accurate estimate for the without-project future condition. Average annual flood damages were calculated with the existing (September, 1990) prices and development. For the purpose of this study, the period of analysis is 50 years and the remaining useful life of all structures was estimated to be 50 years.

EVALUATION OF ALTERNATIVES

This study evaluated building a concrete floodwall on the north bank of the Chattooga River adjacent to the Regal Mill, building an earth levee and concrete floodwall on the south bank adjacent to the school, and raising the height of the existing levee at Frogtown along with clearing the overbank across the river from the levee. These plans were evaluated individually and in combination for a total of seven plans. The alignments are shown on plate 3.

The levee and floodwall adjacent to the school and mill would anchor to the Chattooga and Chickamauga Railway embankment near the trestle. A letter dated February 22, 1991, from the Chattooga and Chickamauga Railway giving their concurrence is contained in Appendix B. As stated in the letter, the railway must approve the final construction plans before work is commenced. It should be noted that the Chattooga and Chickamauga Railway is leasing the railway from the Norfolk Southern Railway. The feasibility study would include engineering investigations of the railroad to determine its stability.

Environmental Impacts. When formulating solutions we coordinated with the U. S. Fish and Wildlife Service to determine if the proposed plans would adversely effect the environment. The Fish and Wildlife Service's field office in Brunswick, Georgia indicated that there would be no significant adverse impacts to fish or wildlife in the study area. However, a Section 404(b)(1) would be required during the feasibility phase.

Cultural Resources. Coordination with the State Historic Preservation Officer indicated that the plans presented in this study would have no effect on historic properties. Further coordination would not be required during feasibility studies unless the plans for the project change.

Alternative Plans.

PLAN 1. This alternative consists of building about a 1500 linear

foot earth levee and reinforced concrete floodwall on the south bank of the Chattooga River. The alignment is shown on plate 3. The top of the levee would be at 665.0 feet NGVD at the point where it ties into the railroad embankment and would increase by 0.3 percent as the structure proceeds upstream.

The 286-foot reach from the railroad to Park Avenue and the 450-foot reach from the pedestrian footbridge to where the levee ties into high ground, would be constructed with an earth embankment. The earth embankment would have 1 vertical on 3 horizontal sideslopes and a top width of 10 feet. The top of the levee would be about 12 to 15 feet above the existing ground elevation. A typical cross section through this reach is shown on plate 4.

The 720-foot reach from Park Avenue to the pedestrian bridge does not have room between the school and river bank for an earth levee 12 to 15 feet in height. Therefore, a reinforced concrete floodwall approximately 5 feet in height would be placed on about 8 feet of earth fill through this reach. A typical cross section through this reach is shown on plate 4.

Since detailed surveys were not available to size ponding areas behind the levee, a conservative approach was taken when designing the interior drainage system. A pump was sized to remove the peak flow for the 100-year flood, thus eliminating the need for ponding areas. The interior peak flow for this event is 350 cfs. The pumping station would be located where the existing storm drainage system empties into the river. If sufficient ponding areas are found, then the pumping cost may be reduced.

PLAN 2. This alternative consists of increasing the top elevation of the SCS levee, shown on plate 3, by about 4 feet to 662.75 feet NGVD. The levee is about 2400 feet long and its elevation is approximately 659.0 feet NGVD. The levee height would be increased by adding earth fill. About 250 feet of cement/sand bags would be used near the two houses located at the southeast end of Frogtown, so that they will not have to be relocated.

Sandbags and earth would be stockpiled to readily place across First Street as a closure structure, between the church and cemetery, as shown on plate 3. Preliminary analyses indicate that backwater from the Chattooga River causes Spring Branch to overflow and enter Frogtown by flowing along First Street. Flood waters backed up this street into Frogtown during the February 1990 flood. First Street is about 1 foot lower than the top elevation of the SCS levee.

PLAN 3. This alternative proposes constructing about a 7-foot in height reinforced concrete floodwall, about 1500 feet in length, on the north bank of the Chattooga River. The floodwall would anchor to the railroad and tie into high ground above the mill. The alignment is shown on Plate 3. The top of the floodwall would be

at 665.0 feet NGVD at the point where it ties into the railroad embankment and would increase by 0.3 percent as the structure proceeds upstream.

In the 286-foot reach between Park Avenue and the railroad, the floodwall would be placed as close as possible to the overbank in the mill parking lot.

There is not room along the overbank in the Regal mill yard, between Park Avenue and the pedestrian bridge, to place the floodwall. Therefore, the overbank in this 720-foot reach would be widened using gabions, as shown on plate 4. The reinforced concrete floodwall would be placed on top of the backfilled area, as shown on plate 4.

To remove interior runoff from behind the floodwall, a pumping station would be constructed in the vicinity of Cane Creek which flows along side the railroad. The pump size used in this study was taken from the SCS publication, "Watershed Work Plan, Headwaters of the Chattooga River Watershed, 1968."

PLAN 4. This alternative consists of Plans 1 and 2.

PLAN 5. This alternative consists of plans 1 and 3.

PLAN 6. This alternative consists of plans 1, 2, and 3.

PLAN 7. This alternative is the same as Plan 2 except that a 220 feet wide by 2000 feet in length area would be cleared across from the Frogtown levee, as shown on Plate 3.

Freeboard and Overtopping. For the purpose of computing the economic benefits, 2 feet of freeboard was allowed for the levees and floodwalls. This was to account for the uncertainties in the water surface profiles. Since the project alignments are relatively short and straight, this was determined to be a reasonable amount of freeboard. Regardless of the amount of freeboard allowed, the levees and floodwall would anchor to existing road or railway embankments at the maximum elevation that would not require extensive and cost prohibitive relocations. Furthermore, the road and railway embankment is relatively flat through this reach and the levees would not increase appreciably in height by extending its length.

It was recognized that sudden failure or overtopping of the levee, especially near the school or residential areas, could be catastrophic. Therefore, consideration was given to control the location of the initial overtopping and thus minimize the effects of a failure. The levee adjacent to Frogtown would be designed to encourage overtopping to start downstream of the residences at the open area used for detention storage. To accomplish this a notch

would be constructed in the freeboard zone of the levee at this location.

Cost. A summary of the project first costs for the 7 plans evaluated in this study is shown in Table 7. A detailed breakdown of the costs for plans 1, 2, 3, and 7 are presented in Tables 1 through 4. The remaining plans are combinations of these 4 basic plans. As shown in tables 1 and 3, the pumping costs are a significant portion of the total project costs. During feasibility, detailed surveys will be made to study the ponding areas. If adequate ponding areas can be designed, then pumping costs may be reduced.

Subsurface conditions often result in major costs for levee construction; however, subsurface investigations were not done for this study. Additional costs for subsurface conditions will be developed during feasibility.

Table 1

Detailed Cost for Plan 1

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST
Reinforced concrete floodwall 7' high				
Reinforced floodwall	720	cy	250	$180,000
Excavation	720	cy	3	2,160
Levee earthfill	15,000	cy	5	75,000
Seeding & mulching-replace topsoil	4	Ac	2,500	10,000
Foundation stripping-stockpile soil	3,000	cy	3	9,000
Road closure structure 5' high				
Reinforced concrete	30	cy	250	7,500
Structural steel (A36) stoplogs	14	tons	2,000	28,000
Pump (340 cfs)	1	job	444,000	444,000
60" dia RC culvert 8' high	200	LF	175	35,000
Precast inlet for 60" culvert 8' high	2	ea	2,000	4,000
Riprap	200	cy	50	10,000
Flapgate w/headwall-60"	2	ea	2,500	5,000
Excavation	1,400	cy	3	4,200
Relocations	1	job	14,000	14,000
Subtotal				827,860
Contingencies (25%)				165,340
Eng. and design				129,000
Real Estate Admin.				25,000
Construction Admin.				50,000
Real Estate Acquisition				25,000
TOTAL PROJECT COST				$1,223,000
Operation and maintenance				100,000
Annual charges				$2,000

Table 1

Detailed Cost for Plan 1

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST
Reinforced concrete floodwall 7' high				
Reinforced floodwall	720	cy	250	$180,000
Excavation	720	cy	3	2,160
Levee earthfill	15,000	cy	5	75,000
Seeding & mulching-replace topsoil	4	Ac	2,500	10,000
Foundation stripping-stockpile soil	3,000	cy	3	9,000
Road closure structure 5' high				
Reinforced concrete	30	cy	250	7,500
Structural steel (A36) stoplogs	14	tons	2,000	28,000
Pump (340 cfs)	1	job	444,000	444,000
60" dia RC culvert 8' high	200	LF	175	35,000
Precast inlet for 60" culvert 8' high	2	ea	2,000	4,000
Riprap	200	cy	50	10,000
Flapgate w/headwall-60"	2	ea	2,500	5,000
Excavation	1,400	cy	3	4,200
Relocations	1	job	14,000	14,000
Subtotal				827,860
Contingencies (25%)				165,340
Eng. and design				129,000
Real Estate Admin.				25,000
Construction Admin.				50,000
Real Estate Acquisition				25,000
TOTAL PROJECT COST				$1,223,000
Operation and maintenance				100,000
Annual charges				$2,000

Table 2

Detailed Cost for Plan 2

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST
Levee earthfill	25,680	cy	3	$77,040
Seeding & mulching-replace topsoil	8	Ac	2,500	20,000
Foundation stripping-stockpile soil	3,500	cy	3	10,500
Overbank clearing	2	Ac	2,000	4,000
36' dia RC culvert	24	LF	60	1,440
Remove inlet struct. for 36' pipe	5	cy	40	200
New inlet structure	5	cy	250	1,250
Cement sand bags	250	LF	74	18,500
Subtotal				132,930
Contingencies (20%)				26,585
Eng. and design				64,603
Construction Admin.				19,055
Real Estate Admin.				15,926
Real Estate Acquisition				42,500
TOTAL PROJECT COST				$301,599
Operation and maintenance				50,000
Annual charges				$1,000

Table 3

Detailed Cost for Plan 3

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST
Reinforced concrete floodwall 7' high	1,345	cy	250	$336,250
Asphalt removal	3,000	sy	1.5	4,500
Asphalt replacement	1,500	sy	6	9,000
Remove & replace 6' fence	800	LF	15	12,000
Gabion wall and backfill				
Gabions	2,680	cy	110	294,800
Fill	2,770	cy	5	13,850
Road closure structure				
Reinforced concrete	30	cy	250	7,500
Structural steel (A36) stoplogs	14	tons	2000	28,000
Pump (250cts)	1	job	380,000	380,000
60" dia RC culvert	120	LF	175	21,000
Precast inlet for 60" culvert 8' high	2	ea	2,000	4,000
Riprap	200	cy	50	10,000
Flapgate w/headwall-60"	2	ea	2,500	5,000
Excavation	1,400	cy	3	4,200
Relocations	1	job	14,000	14,000
Subtotal				1,144,100
Contingencies (25%)				286,025
Eng. and design				129,875
Construction Admin.				74,000
Real Estate Admin.				25,000
Real Estate Acquisition				8,000
TOTAL PROJECT COST				$1,667,000
Operation and maintenance				100,000
Annual charges				$2,000

Table 4

Detailed Cost for Plan 7

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST
Levee earthfill	25,680	cy	3	$77,040
Seeding & mulching-replace top	8	Ac	2,500	20,000
Foundation stripping-stockpile	3,500	cy	3	10,500
Overbank clearing	12	Ac	2,000	24,000
36" dia RC culvert	24	LF	60	1,440
Remove inlet struct. for 36" pipe	5	cy	40	200
New inlet structure	5	cy	250	1,250
Cement/sand bags	250	LF	74	18,500
Subtotal				152,930
Contingencies (20%)				30,586
Eng. and design				64,603
Construction Admin.				19,055
Real Estate Admin.				15,926
Real Estate Acquisition				42,500
TOTAL PROJECT COST				$325,600
Operations and maintenance				50,000
Annual charges				$1,000

Benefit Analysis. The study area was divided into 3 reaches for the purpose of evaluation of benefits. The reaches are identified on plate 2. Based on a windshield survey, the study area has 169 structures valued at $235,264,600 in September 1990. As a percentage of the dollar value of the floodplain, approximately 1 percent of the structural value is commercial, 2 percent is residential and 97 percent is public or industrial. Table 5 displays the number of structures and their aggregate values.

Table 5
Inventory of Property

Category of Property	No. Struct.	$ Value
Residential	154	$3,651,700
Commercial	5	$1,786,500
Industrial + Public	10	$229,826,400
Transportation	0	$0
Utilities + Communications	0	$0
Public Health + Relief	0	$0
Total	169	$235,264,600

The economic benefits associated with each plan are measured by the average annual damages reduced. The damages reduced were based on providing protection to elevation 664.0 feet NGVD for the levee plans in reaches 2 and 3, and to elevation 661.75 feet NGVD for levee plan in reach 1. This includes claiming one-half of the benefits in the freeboard zone. Table 6 lists by category the average annual damages reduced from each plan.

Table 6
Average Annual Damages Reduced by Category
in $1,000

	Plan 1	Plan 2	Plan 3	Plan 4	Plan 5	Plan 6	Plan 7
Res	1.7	28.4	3.6	30.3	5.2	34.3	30.8
Commer	5.8	-0.1	0.0	5.7	5.7	5.7	2.0
Ind & Pub	18.1	-79.1	157.9	-27.0	177.2	177.8	-4.8
Trans.	0.5	-1.0	3.2	0.2	3.8	4.4	0.6
Utilities	0.9	-2.0	6.1	0.3	7.1	8.2	1.0
Health	1.6	-3.4	10.5	0.5	12.2	14.1	1.8
Total	28.6	-57.2	181.3	10.0	211.2	244.5	31.4

As seen in Table 6, plans 2, 4, and 7 induce significant damages to industrial and public facilities, especially to the Regal Mill. Induced damages resulted from increases in the water surface elevation by only a few tenths of a foot.

Economic Evaluation.

Economic evaluations were made using the current Federal interest rate of 8 3/4 percent and a project life of 50 years. The comparison of the benefits versus cost for each plan is presented in the Table 7.

Table 7
Comparison of Benefits versus Cost
in $1,000

Plan Number	First Cost	Annual O & M	Avg Annual Costs	Avg Annual Benefits	Net Benefits	B/C Ratio
1	$1,223	$2	$110.7	$28.6	-82.1	0.26
2	302	1	27.8	-57.2	-85.0	-2.06
3	1,667	2	150.1	181.3	31.2	1.21
4	1,597	3	144.9	10.0	-134.9	0.07
5	2,890	4	260.7	211.2	-49.5	0.81
6	3,264	5	295.0	244.5	-50.5	0.83
7	326	1	29.9	31.4	3.0	1.05

As seen in Table 7, Plans 3 and 7 have benefit to cost ratios greater than unity. However, Plan 3 benefits only the Regal Mill. The "Digest of Water Resources Policies and Authorities", EP 1165-2-1, paragraph 13-11 states, "The Corps will not recommend adoption of a Federal project, or include as a separable element in a recommended structural project plan, flood control improvements which would solely benefit the property of a single owner." Therefore, this plan was eliminated from further consideration. As seen in Table 6, Plan 7 would induce $4,800 annually to industrial and public facilities.

Sensitivity Discussions. While we did not do a sensitivity analysis, we did note that very small increases in the water surface elevation induce significant damages in reach 3 to the Regal Mill This was most notable for plans 2, 4 and 7. These plans increase the water surface elevation by only a few tenths of a foot. Such small measurements of the water surface elevation are beyond the accuracy of the data used in the hydraulic model. Adding to this uncertainty was that the first floor elevations used to compute the economic benefits were not surveyed, but estimated using professional judgement. The B/C ratios are subject to change during feasibility studies.

COST SHARING

We met with the Trion city council on 25 April and presented the findings of the study. While Trion did not commit to feasibility study cost sharing, they did indicate interest in further study of Plan 7. Since the SCS had constructed the levee, we contacted them to find out what programs they had to assist Trion. The SCS indicated they could complete studies and design necessary to implement Plan 7 at 100 percent Federal cost. Furthermore, they indicated they could construct the plan at 100 percent Federal cost, with the non-Federal sponsor providing only LERRD. They also indicated they could study other alternatives at 100 percent Federal cost. We are currently working toward a joint effort between the Corps and the SCS to conduct further studies and implement a project. Trion is very much interested in this approach, since they would only provide the LERRD.

CONCLUSIONS

Our investigations show that there is at least one solution which is in the Federal interest and within the scope of the authority under which this investigation was undertaken. Plans 7 has a benefit to cost ratio of 1.05 and an estimated first cost of $326,116. The estimated cost for the Corps to complete feasibility would be $157,501 with the local sponsor's cash contribution being $73,339. These feasibility study costs are to evaluate several combinations of levee heights for the existing

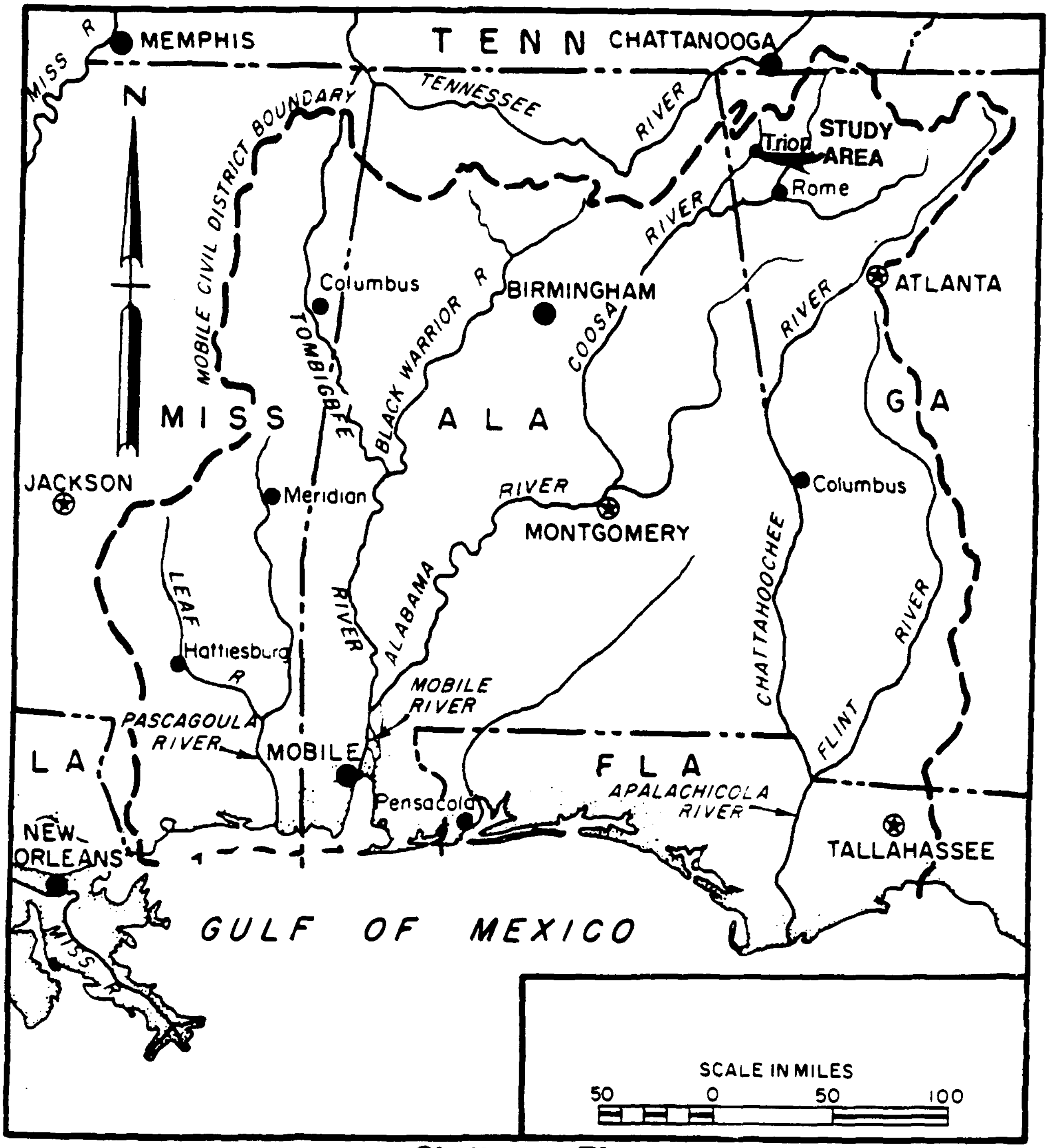
levee and clearing widths in the flood plain. The clearing limits will extend to about 3000 feet below U. S. Highway 27, as requested by the sponsor. This study effort would not evaluate plans upstream of Central Avenue which would involve the railroad. If plans are developed that affect the railroad, additional coordination with the railroad owner will be required. Also, detailed engineering studies would be required to determine the stability of the railroad embankment. Plans involving the railroad may be cost prohibitive. We do not at this time have sufficient data to determine a accurate cost for anchoring to the railroad.

The sponsor has not committed to further studies with the Corps. Since it appears they can achieve the same results with the SCS at virtually no cost, they are unlikely to commit with the Corps. However, we are continuing to work toward a joint effort between the Corps and the SCS, under authorities of the SCS. This would benefit Trion since design and construction would be completed at 100 percent Federal cost. Trion has indicated they could provide the necessary easements and rights-of-way that are required under authorities of the SCS.

RECOMMENDATION

Both the need for flood protection in Trion, Georgia, and a preliminary determination that there is a solution in the Federal interest have been clearly demonstrated. I recommend approval for a feasibility study of the cost and scope developed in this report, subject to an agreement for a joint study and project with the SCS.

MICHAEL F. THUSS
Colonel, Corps of Engineers
Acting District Engineer



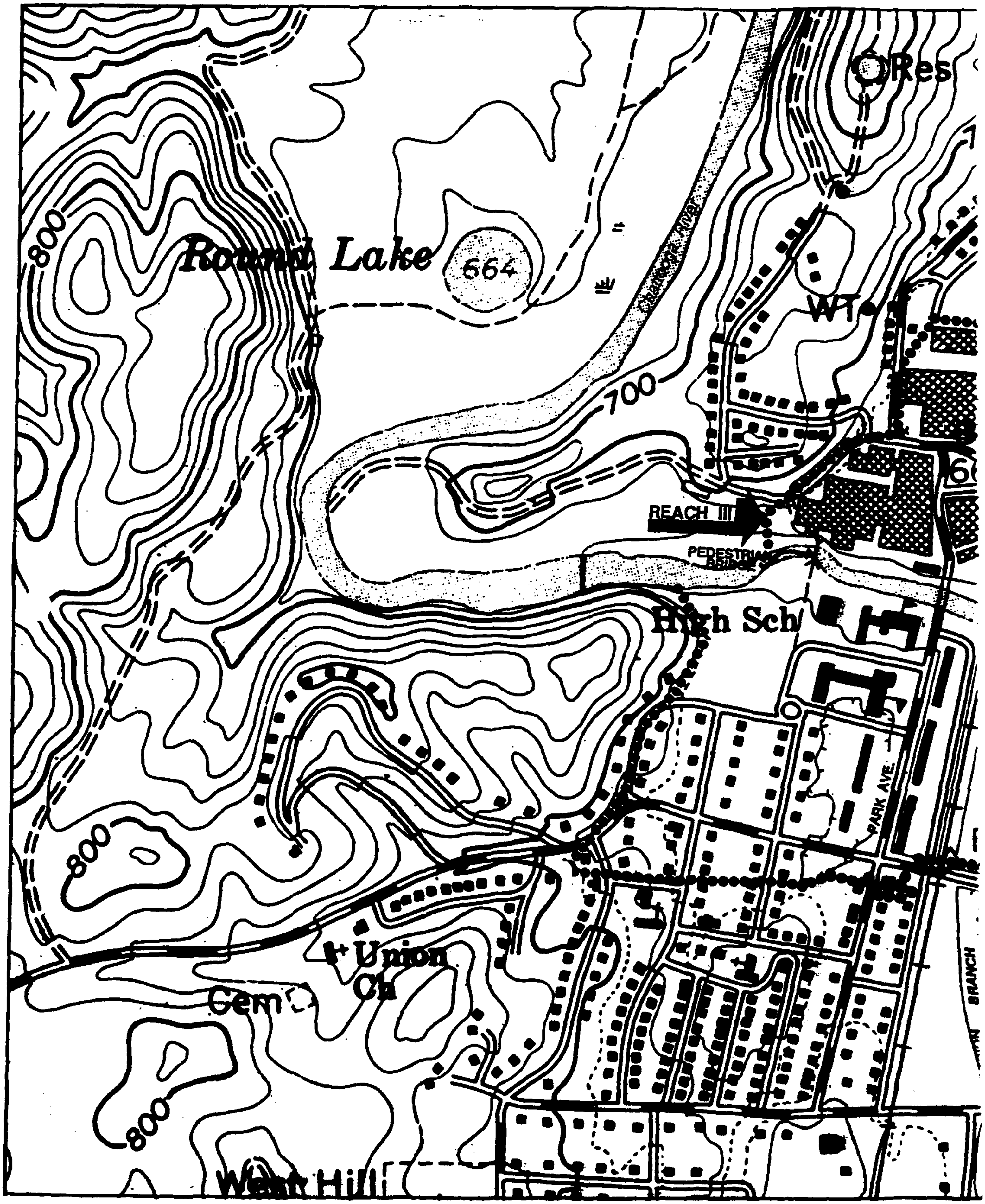
Chattooga River

TRION, GEORGIA

RECONNAISSANCE REPORT

LOCATION MAP

PLATE I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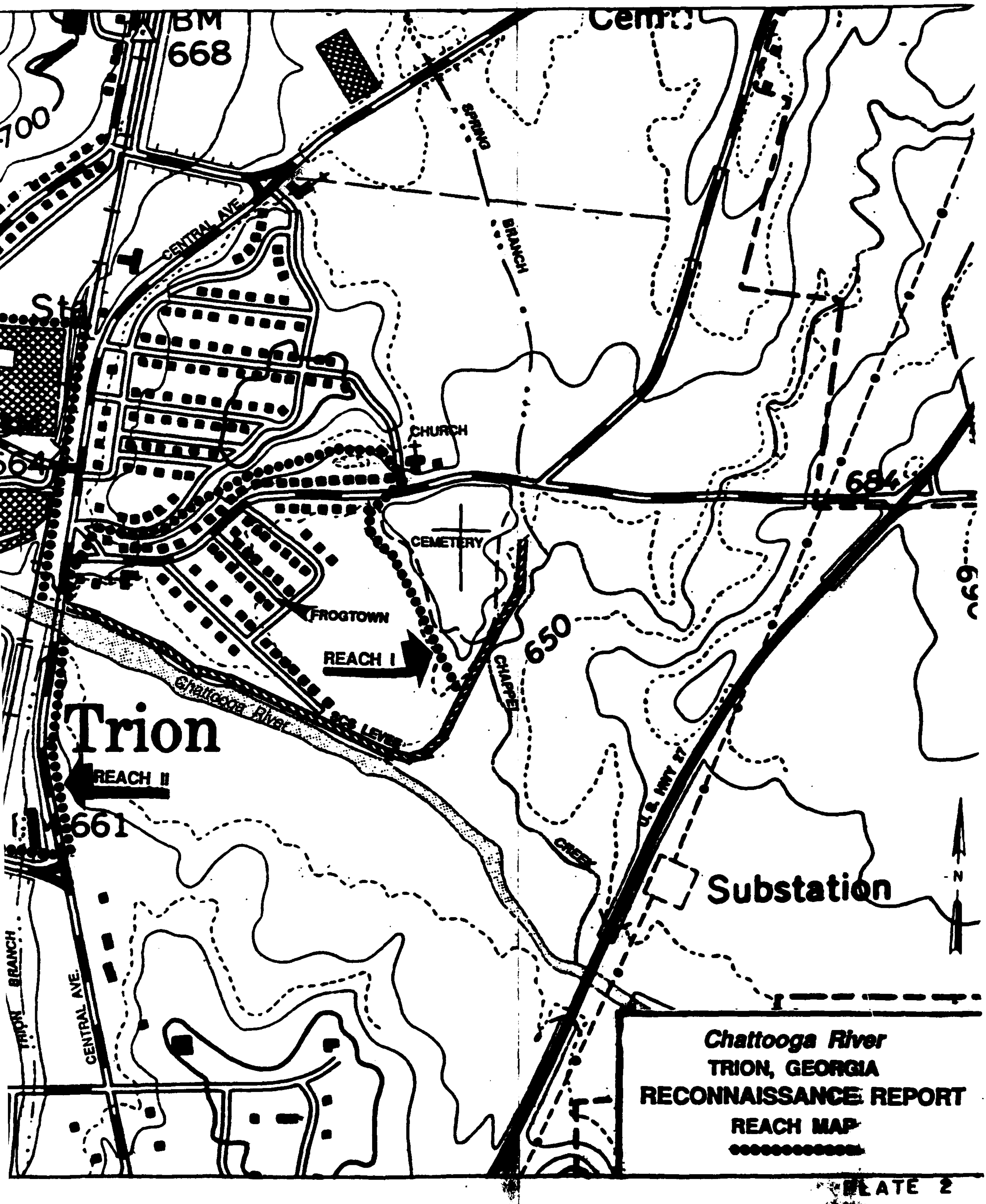
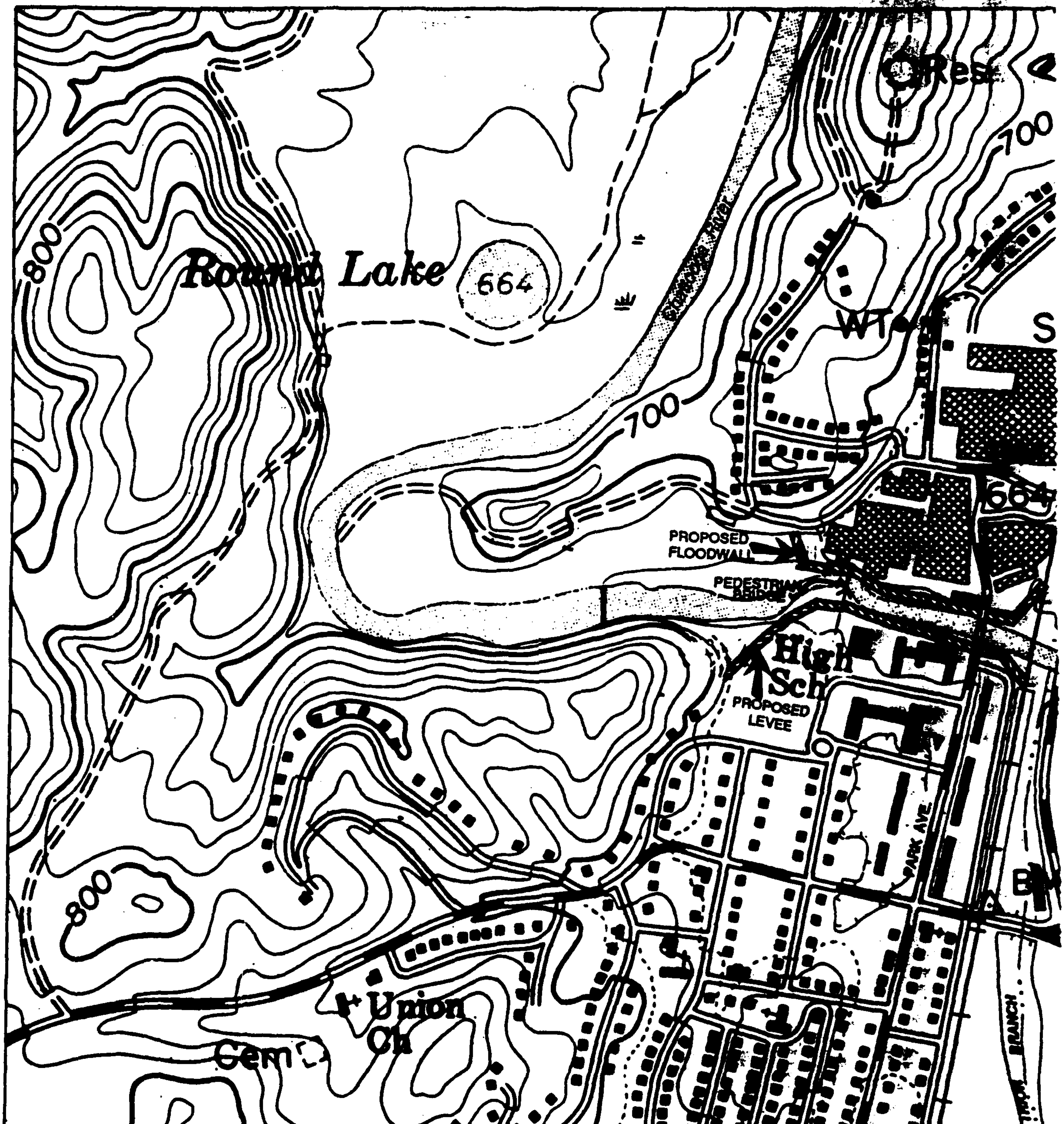
664
800
800
800
800
700
Res
WT
REACH III
PEDESTRIAN BRIDGE
High Sch
PARK AVE.
Union
Ch
Cem
West Hill
BRANCH



Chattooga River
TRION, GEORGIA
RECONNAISSANCE REPORT
REACH MAP

PLATE 2


Round Lake
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PROPOSED
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PEDESTRIAN
BRIDGE
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PARK AVE.
BM
Union
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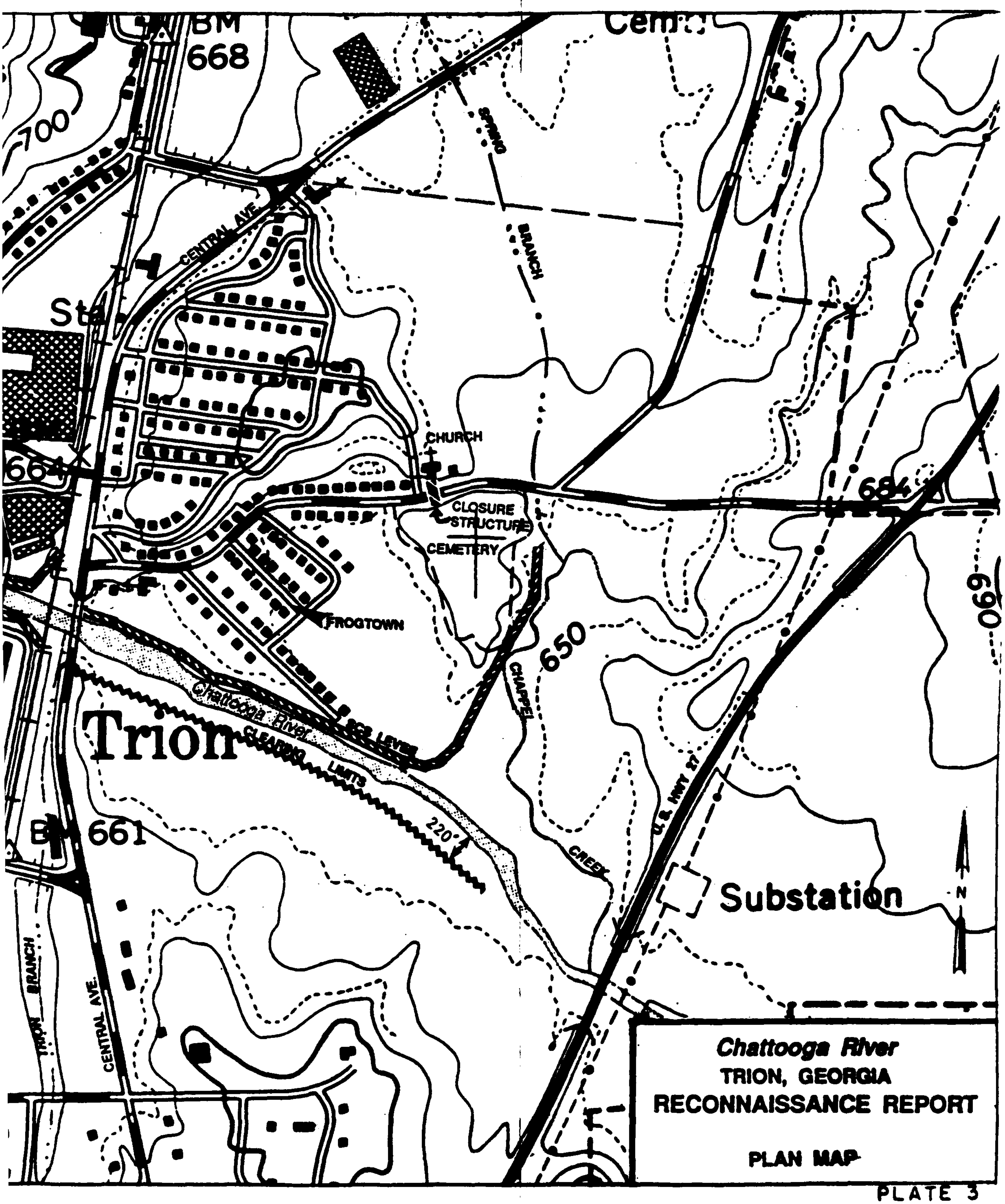
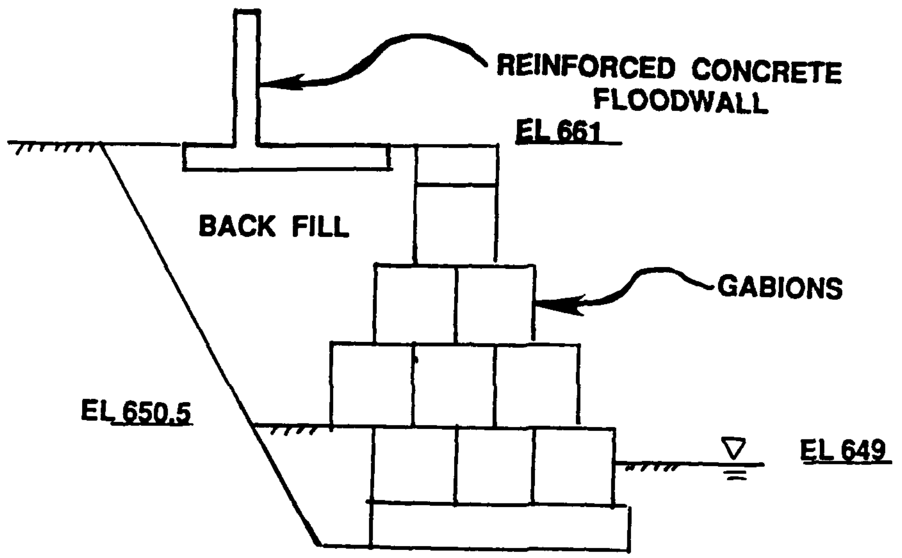
Cem
West Hill



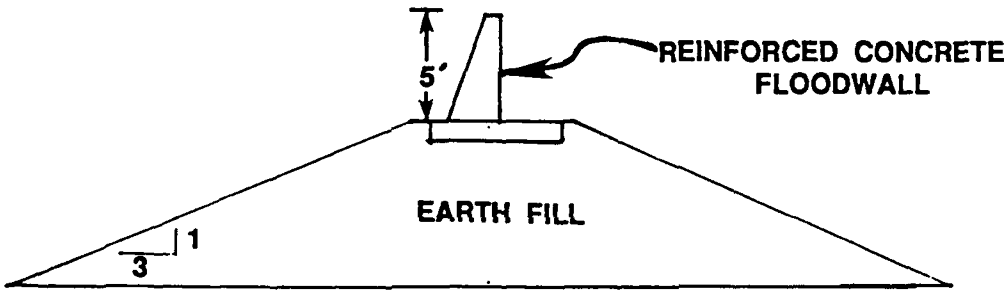
Chattooga River
TRION, GEORGIA
RECONNAISSANCE REPORT

PLAN MAP

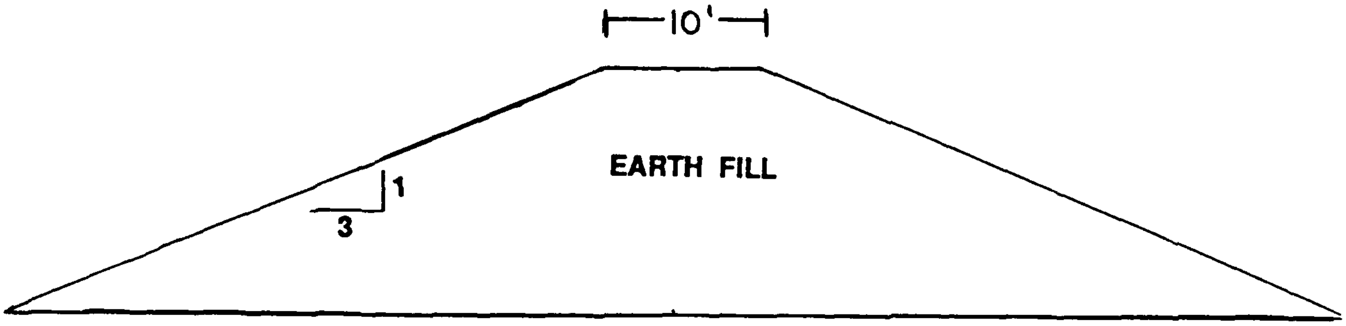
PLATE 3



NORTH OVERBANK ADJACENT TO MILL

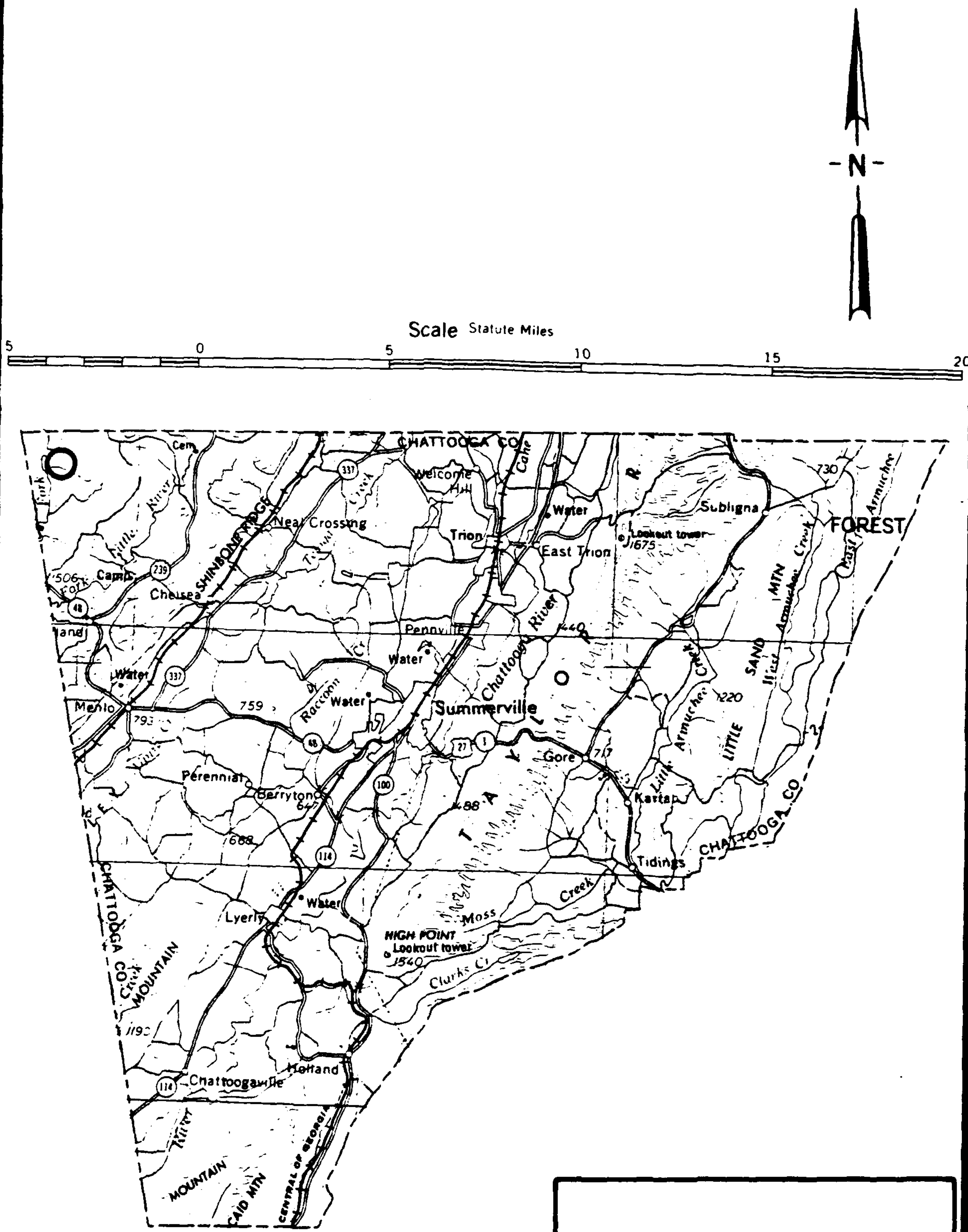


SOUTH OVERBANK ADJACENT TO SCHOOL



SOUTH OVERBANK

CHATTOOGA RIVER
TRION, GEORGIA
RECONNAISSANCE REPORT
TYPICAL CROSS SECTIONS



Chattooga County Map

U.S. ARMY ENGINEER DISTRICT, MOBILE
CORPS OF ENGINEERS
MOBILE, ALABAMA

APPENDIX A

COST FOR PLAN 7

BASE BID

DIVISION 02 SITE WORK		QUANTITY UOM CREW	MANHR	LABOR	EQUIPMENT	MATERIAL	SALESTX	DIRECT $
CD=3 AA 0002 WC=0000	LEVEE EARTHFILL MEMO: ASSUMED MOST MATERIAL WILL BE AVAILABLE AJACENT TO LEVEE. REMAINDER AVAILABLE LESS THAN 3 MILE HAUL.	*** OVERRIDE: Q *** 25680.00 CY N/A	0.00 0	0.00 0	0.00 0	3.00 77,040	0.00 0	3.00 77,040
CD=3 AA 0003 WC=0000	SEED,MULCH - REPLACE TOPSOIL MEMO: TOPSOIL MATERIAL WILL BE AVAILABLE ADJACENT TO THE LEVEE FROM PREVIOUS STRIPPING OPERATION. PRICE INCLUDES MAINTENANCE FOR GRASSING.	*** OVERRIDE: Q *** 8.00 AC N/A	0.00 0	0.00 0	0.00 0	2500.00 20,000	0.00 0	2500.00 20,000
CD=3 AA 0004 WC=0000	FOUNDATION STRIPPING - STOCKPILE MEMO: WILL BE STOCKPILED ADJACENT TO THE LEVEE FOR USE AFTER THE LEVEE HAS BEEN RAISED.	*** OVERRIDE: Q *** 3500.00 CY N/A	0.00 0	0.00 0	0.00 0	3.00 10,500	0.00 0	3.00 10,500
CD=3 AA 0005 WC=0000	OVERBANK CLEARING MEMO: DENSE GROWTH, ASSUMED TO BURN ON SITE.	*** OVERRIDE: Q *** 12.00 AC N/A	0.00 0	0.00 0	0.00 0	2000.00 24,000	0.00 0	2000.00 24,000
CD=3 AA 0007 WC=0000	36" DIA. RC CULVERT	*** UNIT COSTS: *** 24.00 LF N/A	0.00 0	0.00 0	0.00 0	60.00 1,440	0.00 0	60.00 1,440
CD=3 AA 0008 WC=0000	REMOVE INLET STRUCTURE FOR 36" PIPE MEMO: CONCRETE REMOVAL	*** OVERRIDE: Q *** 5.00 CY N/A	0.00 0	0.00 0	0.00 0	40.00 200	0.00 0	40.00 200
CD=3 AA 0009 WC=0000	INLET STRUCTURE MEMO: NEW CONCRETE STRUCTURE	*** OVERRIDE: Q *** 5.00 CY N/A	0.00 0	0.00 0	0.00 0	250.00 1,250	0.00 0	250.00 1,250
CD=3 AA 0010 WC=0000	CEMENT/SAND BAGS MEMO: PRICE IS BASED ON QUOTE FROM W.R. BONSAL CO. OF ATLANTA GA. THE L.F. PRICE IS BASED ON APPROX. 21 BAGS PER L.F. OF LEVEE AND $3.50 PER BAG IN PLACE	*** OVERRIDE: Q *** 250.00 LF N/A	0.00 0	0.00 0	0.00 0	74.00 18,500	0.00 0	74.00 18,500
TOTAL DIVISION 02 SITE WORK			0	0	0	152,930	0	152,930

CREW ID: MOB90A | CURRENCY in DOLLARS | PROJECT ID: TRIREC

REAL ESTATE ESTIMATE FOR PLAN 7
TRION, GEORGIA

Estimate of Cost (date of value: December 1990)

a. Land and Damages		
Land (10 acres)	$30,000	
Improvements	0	
Minerals	0	
Severance	0	
Total land and damages		$30,000
b. Contingencies 25%		7,500
c. Acquisition cost (estimated 1 tract)		5,000
d. PL 91-646		0
e. Total Estimated Real Estate Cost		42,500

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: RE-A Org. Code: RB 04-May-91
ACCOUNT CODE: 01.C
FISCAL YEAR 94

Budget Category	Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
		Direct Charges:		
1) Labor				
Supervisor		Hours		
Engineer		Hours		
Technician		Hours		
Other	30	Hours	$28.85	866
Sub-total Labor	30	Hours		$866
2) Travel & Transportation				
Per Diem		Days		
Govt Vehicle		# Miles		
Commerical Transp.		L.S.		
Sub-total Travel				
3) Supplies & Materials		L.S.		
4) Misc Expense		L.S.		
5) Facility Accounts				
Reproduction		L.S.		
ADP		ADP CPU		
Plant & Equip		Days		
Survey		Days		
Core Drill		Days		
Shops & Yards		Days		
Sub-total Facility Accounts				
6) Contract Payments (A/E, Constr, RE)				
7) Other Corps Payments (eg. 2544's)				
8) Other Government Payments (eg. 1144's)				
Total Direct Charges for Org. Code: RB				$866
		Distributed Charges:		
9) Technical Indirect (Est Rate:)			36.0%	312
10) General Admin (Est Rate:)			24.7%	214
Total Distributed Charges				$525
11) Total Estimated Cost for Account		for	RE-A	$1,391
12) Contingency, Account 01.C.Z		15.0%		$209
13) Total for Account	01.C			$1,599

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: RE-A Org. Code: RB 04-May-91
ACCOUNT CODE: 01.D.1.F
FISCAL YEAR 94

Budget Category		Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
			Direct Charges:		
1) Labor					
	Supervisor		Hours		
	Engineer		Hours		
	Technician		Hours		
	Other	160	Hours	$24.07	3,851
Sub-total Labor		160	Hours		$3,851
2) Travel & Transportation					
	Per Diem		Days		
	Govt Vehicle		# Miles		
Commerical Transp.			L.S.		
Sub-total Travel					
3) Supplies & Materials			L.S.		
4) Misc Expense			L.S.		
5) Facility Accounts					
	Reproduction		L.S.		
	ADP		ADP CPU		
	Plant & Equip		Days		
	Survey		Days		
	Core Drill		Days		
	Shops & Yards		Days		
Sub-total Facility Accounts					
6) Contract Payments (A/E, Constr, RE)					
7) Other Corps Payments (eg. 2544's)					
8) Other Government Payments (eg. 1144's)					
Total Direct Charges for Org. Code: RB					$3,851
			Distributed Charges:		
9) Technical Indirect (Est Rate:)				36.0%	1,386
10) General Admin (Est Rate:)				24.7%	951
Total Distributed Charges					$2,338
11) Total Estimated Cost for Account			for	RE-A	$6,189
12) Contingency, Account		01.D.1.Z	15.0%		$928
13) Total for Account		01.D.1.F			$7,117

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: RE-PC Org. Code: RU 04-May-91
ACCOUNT CODE: 01.D.2
FISCAL YEAR 94

Budget Category		Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
			Direct Charges:		
1) Labor					
	Supervisor		Hours		
	Engineer		Hours		
	Technician		Hours		
	Other	80	Hours	$19.90	1,592
Sub-total Labor		80	Hours		$1,592
2) Travel & Transportation					
	Per Diem		Days		
	Govt Vehicle		# Miles		
	Commerical Transp.		L.S.		
Sub-total Travel					
3) Supplies & Materials			L.S.		
4) Misc Expense			L.S.		
5) Facility Accounts					
	Reproduction		L.S.		
	ADP		ADP CPU		
	Plant & Equip		Days		
	Survey		Days		
	Core Drill		Days		
	Shops & Yards		Days		
Sub-total Facility Accounts					
6) Contract Payments (A/E, Constr, RE)					
7) Other Corps Payments (eg. 2544's)					
8) Other Government Payments (eg. 1144's)					
Total Direct Charges for Org. Code: RU					$1,592
			Distributed Charges:		
9) Technical Indirect (Est Rate:)			36.0%		573
10) General Admin (Est Rate:)			24.7%		393
Total Distributed Charges					$966
11) Total Estimated Cost for Account			for	RE-PC	$2,558
12) Contingency, Account		01.D.2.Z	15.0%		$384
13) Total for Account		01.D.2			$2,942

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: RE-R Org. Code: RC 04-May-91
ACCOUNT CODE: 01.F
FISCAL YEAR 94

Budget Category		Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
			Direct Charges:		
1) Labor					
	Supervisor		Hours		
	Engineer		Hours		
	Technician		Hours		
	Other	48	Hours	$24.07	1,155
Sub-total Labor		48	Hours		$1,155
2) Travel & Transportation					
	Per Diem		Days		
	Govt Vehicle		# Miles		
Commerical Transp.			L.S.		
Sub-total Travel					
3) Supplies & Materials			L.S.		
4) Misc Expense			L.S.		
5) Facility Accounts					
	Reproduction		L.S.		
	ADP		ADP CPU		
	Plant & Equip		Days		
	Survey		Days		
	Core Drill		Days		
	Shops & Yards		Days		
Sub-total Facility Accounts					
6) Contract Payments (A/E, Constr, RE)					
7) Other Corps Payments (eg. 2544's)					
8) Other Government Payments (eg. 1144's)					
Total Direct Charges for Org. Code: RC					$1,155
			Distributed Charges:		
9) Technical Indirect (Est Rate:)				36.0%	416
10) General Admin (Est Rate:)				24.7%	285
Total Distributed Charges					$701
11) Total Estimated Cost for Account			for	RE-R	$1,857
12) Contingency, Account	01.F.Z		15.0%		$278
13) Total for Account	01.F				$2,135

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: RE-A Org. Code: RB 04-May-91
ACCOUNT CODE: 01.H
FISCAL YEAR 94

Budget Category	Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
		Direct Charges:		
1) Labor				
Supervisor		Hours		
Engineer		Hours		
Technician		Hours		
Other	40	Hours	$28.85	1,154
Sub-total Labor	40	Hours		$1,154
2) Travel & Transportation				
Per Diem		Days		
Govt Vehicle		# Miles		
Commerical Transp.		L.S.		
Sub-total Travel				
3) Supplies & Materials		L.S.		
4) Misc Expense		L.S.		
5) Facility Accounts				
Reproduction		L.S.		
ADP		ADP CPU		
Plant & Equip		Days		
Survey		Days		
Core Drill		Days		
Shops & Yards		Days		
Sub-total Facility Accounts				
6) Contract Payments (A/E, Constr, RE)				
7) Other Corps Payments (eg. 2544's)				
8) Other Government Payments (eg. 1144's)				
Total Direct Charges for Org. Code: RB				$1,154
		Distributed Charges:		
9) Technical Indirect (Est Rate:)			36.0%	415
10) General Admin (Est Rate:)			24.7%	285
Total Distributed Charges				$700
11) Total Estimated Cost for Account		for	RE-A	$1,854
12) Contingency, Account	01.H.Z	15.0%		$278
13) Total for Account	01.H			$2,133

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: PD-EI Org. Code: TJ 11-Jun-91
ACCOUNT CODE: 30.H.B
FISCAL YEAR 93

Budget Category		Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
			Direct Charges:		
1) Labor					
	Supervisor		Hours		
	Engineer	8	Hours	$33.50	268
	Technician		Hours		
	Other		Hours		
Sub-total Labor		8	Hours		$268
2) Travel & Transportation					
	Per Diem		Days		
	Govt Vehicle		# Miles		
	Commerical Transp.		L.S.		
Sub-total Travel					
3) Supplies & Materials			L.S.		
4) Misc Expense			L.S.		
5) Facility Accounts					
	Reproduction		L.S.		
	ADP		ADP CPU		
	Plant & Equip		Days		
	Survey		Days		
	Core Drill		Days		
	Shops & Yards		Days		
Sub-total Facility Accounts					
6) Contract Payments (A/E, Constr, RE)					
7) Other Corps Payments (eg. 2544's)					
8) Other Government Payments (eg. 1144's)					
Total Direct Charges for Org. Code: TJ					$268
			Distributed Charges:		
9) Technical Indirect (Est Rate:)				50.0%	134
10) General Admin (Est Rate:)				26.0%	70
Total Distributed Charges					$204
11) Total Estimated Cost for Account				for PD-EI	$472
12) Contingency, Account		30.H.B.Z	20.0%		$94
13) Total for Account		30.H.B			$566

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: EN-DO Org. Code: DE 11-May-91
ACCOUNT CODE: 30.H.B
FISCAL YEAR 93

Budget Category		Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
			Direct Charges:		
1) Labor					
	Supervisor		Hours		
	Engineer	80	Hours	$30.00	2,400
	Technician	4	Hours	$19.00	76
	Other	60	Hours	$11.00	660
Sub-total Labor		144	Hours		$3,136
2) Travel & Transportation					
	Per Diem		Days		
	Govt Vehicle		# Miles		
Commerical Transp.			L.S.		
Sub-total Travel					
3) Supplies & Materials			L.S.		
4) Misc Expense			L.S.		
5) Facility Accounts					
	Reproduction		L.S.		$500
	ADP		ADP CPU		
	Plant & Equip		Days		
	Survey		Days		
	Core Drill		Days		
	Shops & Yards		Days		
Sub-total Facility Accounts					$500
6) Contract Payments (A/E, Constr, RE)					
7) Other Corps Payments (eg. 2544's)					
8) Other Government Payments (eg. 1144's)					
Total Direct Charges for Org. Code: DE					$3,636
			Distributed Charges:		
9) Technical Indirect (Est Rate:)				60.0%	1,882
10) General Admin (Est Rate:)				22.5%	705
Total Distributed Charges					$2,586
11) Total Estimated Cost for Account			for	EN-DO	$6,222
12) Contingency, Account		30.H.B.Z	20.0%		$1,244
13) Total for Account		30.H.B			$7,467

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: EN-FD Org. Code: FD
ACCOUNT CODE: 30.H.B
FISCAL YEAR 92

Budget Category		Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
			Direct Charges:		
1) Labor					
	Supervisor		Hours		
	Engineer	60	Hours	$31.95	1,917
	Technician		Hours		
	Other	40	Hours	$19.47	779
Sub-total Labor		100	Hours		$2,696
2) Travel & Transportation					
	Per Diem		Days		
	Govt Vehicle		# Miles		
	Commerical Trans.		L.S.		
Sub-total Travel					
3) Supplies & Materials			L.S.		
4) Misc Expense			L.S.		
5) Facility Accounts					
	Reproduction		L.S.		
	ADP		ADP CPU		
	Plant & Equip		Days		
	Survey		Days		
	Core Drill		Days		
	Shops & Yards		Days		
Sub-total Facility Accounts					
6) Contract Payments (A/E, Constr, RE)					
7) Other Corps Payments (eg. 2544's)					
8) Other Government Payments (eg. 1144's)					
Total Direct Charges for Org. Code: FD					$2,696
			Distributed Charges:		
9) Technical Indirect (Est Rate:)				60.0%	1,617
10) General Admin (Est Rate:)				22.5%	606
Total Distributed Charges					$2,223
11) Total Estimated Cost for Account			for	EN-FS	$4,919
12) Contingency, Account	30.H.B.Z	10.0%			$492
13) Total for Account	30.H.B				$5,411

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: [illegible] RIVER FLOOD PROTECTION, [illegible], GEORGIA
[illegible]: [illegible] Org. Code: GC 12-Jan-[illegible]
ACCOUNT CODE: [illegible].E
FISCAL YEAR [illegible]

Budget Category		Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
			Direct Charges:		
1) Labor	Supervisor		Hours		
	Engineer	80	Hours	$30.00	2,400
	Technician		Hours		
	Other		Hours		
Sub-total Labor		80	Hours		$2,400
2) Travel & Transportation	Per Diem		Days		
	Govt Vehicle		# Miles		
	Commercial Transp.		L.S.		
Sub-total Travel					
3) Supplies & Materials			L.S.		
Misc Expenses			L.S.		
5 Facility Accounts	Reproduction		L.S.		
	ADP		ADP CPU		
	Plant & Equip		Days		
	Survey		Days		
	Core Drill		Days		
	Shops & Yards		Days		
Sub-total Facility Accounts					
6) Contract Payments (A/E, Constr, RE)					
7) Other Corps Payments (eg. 2544's)					
8) Other Government Payments (eg. 1144's)					
Total Direct Charges for Org. Code:			GC		$2,400
			Distributed Charges:		
9) Technical Indirect (Est Rate:)				60.0%	1,440
10) General Admin (Est Rate:)				22.5%	539
Total Distributed Charges					$1,979
11) Total Estimated Cost for Account			for EN-YD		$4,379
12) Contingency, Account		30.H.B.Z		20.0%	$876
13) Total for Account		30.H.B			$5,255

NOTE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: EN-MC Org. Code: HK 04-May-91
ACCOUNT CODE: 30.H.B
FISCAL YEAR 93

Budget Category		Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
			Direct Charges:		
1) Labor					
	Supervisor		Hours		
	Engineer	80	Hours	$35.00	2,800
	Technician		Hours		
	Other	16	Hours	$10.00	160
Sub-total Labor		96	Hours		$2,960
2) Travel & Transportation					
	Per Diem		Days		
	Govt Vehicle		# Miles		
	Commerical Transp.		L.S.		
Sub-total Travel					
3) Supplies & Materials			L.S.		
4) Misc Expense			L.S.		
5) Facility Accounts					
	Reproduction		L.S.		
	ADP		ADP CPU		
	Plant & Equip		Days		
	Survey		Days		
	Core Drill		Days		
	Shops & Yards		Days		
Sub-total Facility Accounts					
6) Contract Payments (A/E, Constr, RE)					
7) Other Corps Payments (eg. 2544's)					
8) Other Government Payments (eg. 1144's)					
Total Direct Charges for Org. Code: HK					$2,960
			Distributed Charges:		
9) Technical Indirect (Est Rate:)				60.0%	1,776
10) General Admin (Est Rate:)				22.5%	665
Total Distributed Charges					$2,441
11) Total Estimated Cost for Account			for	EN-MC	$5,401
12) Contingency, Account		30.H.B.Z	20.0%		$1,080
13) Total for Account		30.H.B			$6,481

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: PD-ES Org. Code: TS 04-May-91
ACCOUNT CODE: 30.H.B
FISCAL YEAR 93

Budget Category	Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
		Direct Charges:		
1) Labor				
Supervisor		Hours		
Engineer	32	Hours	$27.40	877
Technician		Hours		
Other		Hours		
Sub-total Labor	32	Hours		$877
2) Travel & Transportation				
Per Diem		Days		
Govt Vehicle		# Miles		
Commerical Transp.		L.S.		
Sub-total Travel				
3) Supplies & Materials		L.S.		
4) Misc Expense		L.S.		
5) Facility Accounts				
Reproduction		L.S.		
ADP		ADP CPU		
Plant & Equip		Days		
Survey		Days		
Core Drill		Days		
Shops & Yards		Days		
Sub-total Facility Accounts				
6) Contract Payments (A/E, Constr, RE)			+	
7) Other Corps Payments (eg. 2544's)				
8) Other Government Payments (eg. 1144's)				
Total Direct Charges for Org. Code: TS				$877
		Distributed Charges:		
9) Technical Indirect (Est Rate:)			51.0%	447
10) General Admin (Est Rate:)			22.4%	196
Total Distributed Charges				$644
11) Total Estimated Cost for Account			for PD-ES	$1,520
12) Contingency, Account 30.H.B.Z		25.0%		$380
13) Total for Account 30.H.B				$1,900

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: PD-ES Org. Code: TS 04-May-91
ACCOUNT CODE: 30.H.C
FISCAL YEAR 93

Budget Category		Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
			Direct Charges:		
1) Labor					
	Supervisor		Hours		
	Engineer	24	Hours	$27.40	658
	Technician		Hours		
	Other		Hours		
Sub-total Labor		24	Hours		$658
2) Travel & Transportation					
	Per Diem		Days		
	Govt Vehicle		# Miles		
	Commerical Transp.		L.S.		
Sub-total Travel					
3) Supplies & Materials			L.S.		
4) Misc Expense			L.S.		
5) Facility Accounts					
	Reproduction		L.S.		
	ADP		ADP CPU		
	Plant & Equip		Days		
	Survey		Days		
	Core Drill		Days		
	Shops & Yards		Days		
Sub-total Facility Accounts					
6) Contract Payments (A/E, Constr, RE)				+	
7) Other Corps Payments (eg. 2544's)					
8) Other Government Payments (eg. 1144's)					
Total Direct Charges for Org. Code: TS					$658
			Distributed Charges:		
9) Technical Indirect (Est Rate:)			51.0%		335
10) General Admin (Est Rate:)			22.4%		147
Total Distributed Charges					$483
11) Total Estimated Cost for Account			for	PD-ES	$1,140
12) Contingency, Account	30.H.C.Z		33.3%		$380
13) Total for Account	30.H.C				$1,520

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: PD-ES Org. Code: TS 04-May-91
ACCOUNT CODE: 30.J.2
FISCAL YEAR 94

Budget Category		Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
			Direct Charges:		
1) Labor					
	Supervisor		Hours		
	Engineer	24	Hours	$27.40	658
	Technician		Hours		
	Other		Hours		
Sub-total Labor		24	Hours		$658
2) Travel & Transportation					
	Per Diem	3	Days	$66.00	$198
	Govt Vehicle	1000	# Miles	$0.24	$240
Commerical Transp.			L.S.		
Sub-total Travel					$438
3) Supplies & Materials			L.S.		
4) Misc Expense			L.S.		$100
5) Facility Accounts					
	Reproduction		L.S.		
	ADP		ADP CPU		
	Plant & Equip		Days		
	Survey		Days		
	Core Drill		Days		
	Shops & Yards		Days		
Sub-total Facility Accounts					
6) Contract Payments (A/E, Constr, RE)				+	
7) Other Corps Payments (eg. 2544's)					
8) Other Government Payments (eg. 1144's)					
Total Direct Charges for Org. Code: TS					$1,196
			Distributed Charges:		
9) Technical Indirect (Est Rate:)			51.0%		335
10) General Admin (Est Rate:)			22.4%		147
Total Distributed Charges					$483
11) Total Estimated Cost for Account			for	PD-ES	$1,678
12) Contingency, Account	30.J.2.Z		33.3%		$559
13) Total for Account	30.J.2				$2,237

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: EN-FS Org. Code: FD 04-May-91
ACCOUNT CODE: 30.J.2
FISCAL YEAR 94

Budget Category	Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
		Direct Charges:		
1) Labor				
Supervisor		Hours		
Engineer	40	Hours	$31.95	1,278
Technician		Hours		
Other		Hours		
Sub-total Labor	40	Hours		$1,278
2) Travel & Transportation				
Per Diem	2	Days	$66.00	$132
Govt Vehicle	800	# Miles	$0.26	$208
Commerical Transp.		L.S.		
Sub-total Travel				$340
3) Supplies & Materials		L.S.		
4) Misc Expense		L.S.		
5) Facility Accounts				
Reproduction		L.S.		
ADP		ADP CPU		
Plant & Equip		Days		
Survey		Days		
Core Drill		Days		
Shops & Yards		Days		
Sub-total Facility Accounts				
6) Contract Payments (A/E, Constr, RE)				
7) Other Corps Payments (eg. 2544's)				
8) Other Government Payments (eg. 1144's)				
Total Direct Charges for Org. Code: FD				$1,618
		Distributed Charges:		
9) Technical Indirect (Est Rate:)			60.0%	767
10) General Admin (Est Rate:)			22.5%	287
Total Distributed Charges				$1,054
11) Total Estimated Cost for Account		for	EN-FS	$2,672
12) Contingency, Account	30.J.2.Z	10.0%		$267
13) Total for Account	30.J.2			$2,939

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: EN-DO Org. Code: DE 04-May-91
ACCOUNT CODE: 30.J.9
FISCAL YEAR 94

Budget Category		Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
			Direct Charges:		
1) Labor					
	Supervisor		Hours		
	Engineer	40	Hours	$30.00	1,200
	Technician		Hours		
	Other	60	Hours	$11.00	660
Sub-total Labor		100	Hours		$1,860
2) Travel & Transportation					
	Per Diem		Days		
	Govt Vehicle		# Miles		
	Commerical Transp.		L.S.		
Sub-total Travel					
3) Supplies & Materials			L.S.		
4) Misc Expense			L.S.		
5) Facility Accounts					
	Reproduction		L.S.		$1,000
	ADP		ADP CPU		
	Plant & Equip		Days		
	Survey		Days		
	Core Drill		Days		
	Shops & Yards		Days		
Sub-total Facility Accounts					$1,000
6) Contract Payments (A/E, Constr, RE)					
7) Other Corps Payments (eg. 2544's)					
8) Other Government Payments (eg. 1144's)					
Total Direct Charges for Org. Code: DE					$2,860
			Distributed Charges:		
9) Technical Indirect (Est Rate:)				60.0%	1,116
10) General Admin (Est Rate:)				22.5%	418
Total Distributed Charges					$1,534
11) Total Estimated Cost for Account			for	EN-DO	$4,394
12) Contingency, Account		30.J.9.Z	20.0%		$879
1[illegible] Total for Account		30.J.9			$5,273

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: EN-YD Org. Code: GC 04-May-91
ACCOUNT CODE: 30.J.9
FISCAL YEAR 94

Budget Category		Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
			Direct Charges:		
1) Labor					
	Supervisor		Hours		
	Engineer	40	Hours	$30.00	1,200
	Technician		Hours		
	Other		Hours		
Sub-total Labor		40	Hours		$1,200
2) Travel & Transportation					
	Per Diem		Days		
	Govt Vehicle		# Miles		
Commerical Transp.			L.S.		
Sub-total Travel					
3) Supplies & Materials			L.S.		
4) Misc Expense			L.S.		
5) Facility Accounts					
	Reproduction		L.S.		
	ADP		ADP CPU		
	Plant & Equip		Days		
	Survey		Days		
	Core Drill		Days		
	Shops & Yards		Days		
Sub-total Facility Accounts					
6) Contract Payments (A/E, Constr, RE)				+	
7) Other Corps Payments (eg. 2544's)					
8) Other Government Payments (eg. 1144's)					
Total Direct Charges for Org. Code: GC					$1,200
			Distributed Charges:		
9) Technical Indirect (Est Rate:)			60.0%		720
10) General Admin (Est Rate:)			22.5%		270
Total Distributed Charges					$990
11) Total Estimated Cost for Account			for	EN-YD	$2,190
12) Contingency, Account		30.J.9.Z	20.0%		$438
13) Total for Account		30.J.9			$2,628

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: EN-MC Org. Code: HK 04-May-91
ACCOUNT CODE: 30.J.9
FISCAL YEAR 94

Budget Category		Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
			Direct Charges:		
1) Labor					
	Supervisor		Hours		
	Engineer	40	Hours	$35.00	1,400
	Technician		Hours		
	Other	16	Hours	$10.00	160
Sub-total Labor		56	Hours		$1,560
2) Travel & Transportation					
	Per Diem		Days		
	Govt Vehicle		# Miles		
	Commerical Transp.		L.S.		
Sub-total Travel					
3) Supplies & Materials			L.S.		
4) Misc Expense			L.S.		
5) Facility Accounts					
	Reproduction		L.S.		
	ADP		ADP CPU		
	Plant & Equip		Days		
	Survey		Days		
	Core Drill		Days		
	Shops & Yards		Days		
Sub-total Facility Accounts					
6) Contract Payments (A/E, Constr, RE)					
7) Other Corps Payments (eg. 2544's)					
8) Other Government Payments (eg. 1144's)					
Total Direct Charges for Org. Code: HK					$1,560
			Distributed Charges:		
9) Technical Indirect (Est Rate:)			60.0%		936
10) General Admin (Est Rate:)			22.5%		351
Total Distributed Charges					$1,287
11) Total Estimated Cost for Account			for	EN-MC	$2,847
12) Contingency, Account		30.J.9.Z	20.0%		$569
13) Total for Account		30.J.9			$3,416

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: EN-EC Org. Code: DC 11-May-91
ACCOUNT CODE: 30.M
FISCAL YEAR 93

Budget Category		Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
			Direct Charges:		
1) Labor					
	Supervisor		Hours		
	Engineer	60	Hours	$35.00	2,100
	Technician		Hours		
	Other		Hours		
Sub-total Labor		60	Hours		$2,100
2) Travel & Transportation					
	Per Diem		Days		
	Govt Vehicle		# Miles		
Commerical Transp.			L.S.		
Sub-total Travel					
3) Supplies & Materials			L.S.		
4) Misc Expense			L.S.		
5) Facility Accounts					
	Reproduction		L.S.		$100
	ADP		ADP CPU		
	Plant & Equip		Days		
	Survey		Days		
	Core Drill		Days		
	Shops & Yards		Days		
Sub-total Facility Accounts					$100
6) Contract Payments (A/E, Constr, RE)					
7) Other Corps Payments (eg. 2544's)					
8) Other Government Payments (eg. 1144's)					
Total Direct Charges for Org. Code: DC					$2,200
			Distributed Charges:		
9) Technical Indirect (Est Rate:)			60.0%		1,260
10) General Admin (Est Rate:)			24.7%		519
Total Distributed Charges					$1,779
11) Total Estimated Cost for Account			for	EN-EC	$3,979
12) Contingency, Account	30.M.Z		20.0%		$796
13) Total for Account	30.M				$4,774

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: EN-EC Org. Code: DC 04-May-91
ACCOUNT CODE: 30.M
FISCAL YEAR 94

Budget Category	Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
		Direct Charges:		
1) Labor				
Supervisor		Hours		
Engineer	16	Hours	$35.00	560
Technician		Hours		
Other		Hours		
Sub-total Labor	16	Hours		$560
2) Travel & Transportation				
Per Diem		Days		
Govt Vehicle		# Miles		
Commerical Transp.		L.S.		
Sub-total Travel				
3) Supplies & Materials		L.S.		
4) Misc Expense		L.S.		
5) Facility Accounts				
Reproduction		L.S.		$50
ADP		ADP CPU		
Plant & Equip		Days		
Survey		Days		
Core Drill		Days		
Shops & Yards		Days		
Sub-total Facility Accounts				$50
6) Contract Payments (A/E, Constr, RE)				
7) Other Corps Payments (eg. 2544's)				
8) Other Government Payments (eg. 1144's)				
Total Direct Charges for Org. Code: DC				$610
		Distributed Charges:		
9) Technical Indirect (Est Rate:)			60.0%	336
10) General Admin (Est Rate:)			24.7%	138
Total Distributed Charges				$474
11) Total Estimated Cost for Account		for	EN-EC	$1,084
12) Contingency, Account 30.M.Z		20.0%		$217
13) Total for Account 30.M				$1,301

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: EN-DO Org. Code: DE 04-May-91
ACCOUNT CODE: 30.N.1
FISCAL YEAR 93

Budget Category	Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
Direct Charges:				
1) Labor				
Supervisor		Hours		
Engineer	40	Hours	$30.00	1,200
Technician	4	Hours	$19.00	76
Other	40	Hours	$11.00	440
Sub-total Labor	84	Hours		$1,716
2) Travel & Transportation				
Per Diem		Days		
Govt Vehicle		# Miles		
Commerical Transp.		L.S.		
Sub-total Travel				
3) Supplies & Materials		L.S.		
4) Misc Expense		L.S.		
5) Facility Accounts				
Reproduction		L.S.		$3,000
ADP		ADP CPU		
Plant & Equip		Days		
Survey		Days		
Core Drill		Days		
Shops & Yards		Days		
Sub-total Facility Accounts				$3,000
6) Contract Payments (A/E, Constr, RE)				
7) Other Corps Payments (eg. 2544's)				
8) Other Government Payments (eg. 1144's)				
Total Direct Charges for Org. Code: DE				$4,716
Distributed Charges:				
9) Technical Indirect (Est Rate:)			60.0%	1,030
10) General Admin (Est Rate:)			22.5%	386
Total Distributed Charges				$1,415
11) Total Estimated Cost for Account		for	EN-DO	$6,131
12) Contingency, Account	30.N.1.Z	10.0%		$613
13) Total for Account	30.N.1			$6,744

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: PD-FP Org. Code: TD 11-May-91
ACCOUNT CODE: 30.P
FISCAL YEAR 93

Budget Category		Amount	Typical Staff Element Variable	Aver Effective Rate	Cost Estimate
			Direct Charges:		
1) Labor					
	Supervisor		Hours		
	Engineer	40	Hours	$31.00	1,240
	Technician		Hours		
	Other		Hours		
Sub-total Labor		40	Hours		$1,240
2) Travel & Transportation					
	Per Diem		Days		
	Govt Vehicle		# Miles		
	Commerical Transp.		L.S.		
Sub-total Travel					
3) Supplies & Materials			L.S.		
4) Misc Expense			L.S.		
5) Facility Accounts					
	Reproduction		L.S.		
	ADP		ADP CPU		
	Plant & Equip		Days		
	Survey		Days		
	Core Drill		Days		
	Shops & Yards		Days		
Sub-total Facility Accounts					
6) Contract Payments (A/E, Constr, RE)					
7) Other Corps Payments (eg. 2544's)					
8) Other Government Payments (eg. 1144's)					
Total Direct Charges for Org. Code: TD					$1,240
			Distributed Charges:		
9) Technical Indirect (Est Rate:)			60.0%		744
10) General Admin (Est Rate:)			22.5%		279
Total Distributed Charges					$1,023
11) Total Estimated Cost for Account			for	PD-FP	$2,263
12) Contingency, Account		30.P.Z	20.0%		$453
13) Total for Account		30.P			$2,716

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: PD-FP Org. Code: TD 11-May-91
ACCOUNT CODE: 30.P
FISCAL YEAR 94

Budget Category	Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
		Direct Charges:		
1) Labor				
Supervisor		Hours		
Engineer	60	Hours	$31.00	1,860
Technician		Hours		
Other		Hours		
Sub-total Labor	60	Hours		$1,860
2) Travel & Transportation				
Per Diem	3	Days	$66.00	$198
Govt Vehicle	800	# Miles	$0.24	$192
Commerical Transp.		L.S.		
Sub-total Travel				$390
3) Supplies & Materials		L.S.		
4) Misc Expense		L.S.		
5) Facility Accounts				
Reproduction		L.S.		
ADP		ADP CPU		
Plant & Equip		Days		
Survey		Days		
Core Drill		Days		
Shops & Yards		Days		
Sub-total Facility Accounts				
6) Contract Payments (A/E, Constr, RE)				
7) Other Corps Payments (eg. 2544's)				
8) Other Government Payments (eg. 1144's)				
Total Direct Charges for Org. Code: TD				$2,250
		Distributed Charges:		
9) Technical Indirect (Est Rate:)			60.0%	1,116
10) General Admin (Est Rate:)			22.5%	419
Total Distributed Charges				$1,535
11) Total Estimated Cost for Account		for	PD-FP	$3,785
12) Contingency, Account	30.P.Z	20.0%		$757
13) Total for Account	30.P			$4,541

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: CO-PM Org. Code: C2 04-May-91
ACCOUNT CODE: 31.B
FISCAL YEAR 94

Budget Category	Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
		Direct Charges:		
1) Labor				
Supervisor		Hours		
Engineer	45	Hours	$35.00	1,575
Technician		Hours		
Other		Hours		
Sub-total Labor	45	Hours		$1,575
2) Travel & Transportation				
Per Diem		Days		
Govt Vehicle		# Miles		
Commerical Transp.		L.S.		
Sub-total Travel				
3) Supplies & Materials		L.S.		$8
4) Misc Expense		L.S.		
5) Facility Accounts				
Reproduction		L.S.		
ADP		ADP CPU		
Plant & Equip		Days		
Survey		Days		
Core Drill		Days		
Shops & Yards		Days		
Sub-total Facility Accounts				
6) Contract Payments (A/E, Constr, RE)			+	
7) Other Corps Payments (eg. 2544's)				
8) Other Government Payments (eg. 1144's)				
Total Direct Charges for Org. Code: C2				$1,583
		Distributed Charges:		
9) Technical Indirect (Est Rate:)		26.0%		410
10) General Admin (Est Rate:)		38.0%		599
Total Distributed Charges				$1,008
11) Total Estimated Cost for Account		for	CO-PM	$2,591
12) Contingency, Account	31.B.Z	10.0%		$259
13) Total for Account	31.B			$2,850

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: CO-PM Org. Code: C2 04-May-91
ACCOUNT CODE: 31.E
FISCAL YEAR 94

Budget Category		Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
			Direct Charges:		
1) Labor					
	Supervisor		Hours		
	Engineer	213	Hours	$35.00	7,455
	Technician		Hours		
	Other		Hours		
		-------			--------
Sub-total Labor		213	Hours		$7,455
2) Travel & Transportation					
	Per Diem	24	Days	$25.00	$600
	Govt Vehicle	4608	# Miles	$0.24	$1,106
Commerical Transp.			L.S.		

Sub-total Travel					$1,706
3) Supplies & Materials			L.S.		$226
4) Misc Expense			L.S.		$138
5) Facility Accounts					
	Reproduction		L.S.		
	ADP		ADP CPU		
	Plant & Equip		Days		
	Survey		Days		
	Core Drill		Days		
	Shops & Yards		Days		

Sub-total Facility Accounts					
6) Contract Payments (A/E, Constr, RE)				+	
7) Other Corps Payments (eg. 2544's)					
8) Other Government Payments (eg. 1144's)					
					===============
Total Direct Charges for Org. Code: C2					$9,525
			Distributed Charges:		
9) Technical Indirect (Est Rate:)			26.0%		1,938
10) General Admin (Est Rate:)			38.0%		2,833

Total Distributed Charges					$4,771
					===============
11) Total Estimated Cost for Account			for	CO-PM	$14,296
12) Contingency, Account		31.E.Z			
					===============
13) Total for Account		31.E			$14,296

SCOPE:

Cost Estimate for Engineering and Design Effort

PROJECT: CHATTOOGA RIVER FLOOD PROTECTION, TRION, GEORGIA
TECH ELEMENT: CO-PM Org. Code: C2 04-May-91
ACCOUNT CODE: 31.P
FISCAL YEAR 94

Budget Category		Amount	Variable	Typical Staff Element Aver Effective Rate	Cost Estimate
			Direct Charges:		
1) Labor					
	Supervisor		Hours		
	Engineer	25	Hours	$35.00	875
	Technician		Hours		
	Other		Hours		
Sub-total Labor		25	Hours		$875
2) Travel & Transportation					
	Per Diem	5	Days	$25.00	$125
	Govt Vehicle	960	# Miles	$0.24	$230
Commerical Transp.			L.S.		
Sub-total Travel					$355
3) Supplies & Materials			L.S.		$119
4) Misc Expense			L.S.		
5) Facility Accounts					
	Reproduction		L.S.		
	ADP		ADP CPU		
	Plant & Equip		Days		
	Survey		Days		
	Core Drill		Days		
	Shops & Yards		Days		
Sub-total Facility Accounts					
6) Contract Payments (A/E, Constr, RE)					
7) Other Corps Payments (eg. 2544's)					
8) Other Government Payments (eg. 1144's)					
Total Direct Charges for Org. Code: C2					$1,349
			Distributed Charges:		
9) Technical Indirect (Est Rate:)				26.0%	228
10) General Admin (Est Rate:)				38.0%	333
Total Distributed Charges					$560
11) Total Estimated Cost for Account			for	CO-PM	$1,909
12) Contingency, Account 31.P.Z					
13) Total for Account 31.P					$1,909

SCOPE:

APPENDIX B

CORRESPONDENCE

TOWN OF TRION

TRION, GEORGIA 30753

April 16, 1990

Colonel Larry Bonine
District Engineer
U.S. Army Corp. of Engineers
Mobile District
P.O. Box 2288
Mobile, Alabama 36628

Dear Sir:

Due to the recent flooding in February and March, of the Town of Trion, in which a large number of residents were forced out of their homes, I would like to request a Flood Control Study.

Please advise of anyway I may assist, and I await your reply.

Yours very truly,

J. Hoyt Williams, Sr.

J. Hoyt Williams, Sr.
Mayor

JHWSR/csm

CHATTOOGA & CHICKAMAUGA RAILWAY CO.

P.O. Box 2385
Columbus, MS 39704

201 19th St. N.
Columbus, MS 39701

(601) 329-7737
FAX (601) 329-7724

February 22, 1991

Mr. Bob Allen
U.S. Corps of Engineers
P. O. Box 2288
Mobile, Al,, 36628-0001

Dear Mr. Allen:

With reference to your several telephone conversations with Mr. Harold O. Holiman of Lafayette, Georgia, General Manager of the Chattooga and Chickamauga Railway Company, relative to the flood control project of the Corps of Engineers at Trion, Georgia, this letter is to advise that the Railway does not have any objections in principle to anchoring a levee to the railroad embankment.

However, formal approval of any entry or construction upon railroad property must be contingent upon your submission and our approval of the final construction plans and issuance of a license before work is commenced. We must be certain that the proposed structure does not adversely affect the structual integrity of the roadbed or interfere with or alter its drainage.

Additionally, please be advised that the Chattooga and Chickamauga Railway Company is only the lessee and operator of the railroad under a 25-year lease with option to purchase from the Central of Georgia Railroad Company, a subsidiary of Norfolk Southern. Therefore, while our approval will be required, it will limited to the extent of our interest in the property under the lease.

If we may be of further assistance, please let us know.

Sincerely yours,

Wm. O. Burgin, Jr.
Wm. O. Burgin, Jr.
Administrative Assistant

cc: Roger D. Bell
Harold O. Holiman
Wayne Carver

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

March 21, 1991

REPLY TO
ATTENTION OF:

Plan Development Section

Honorable J. Hoyt Williams, Sr.
Mayor of Trion
128 Park Avenue
Trion, Georgia 30753

Dear Mayor Williams:

In April 1990, you requested that the Corps of Engineers perform a Section 205 Flood Control Study for Trion, Georgia. We are about to complete the reconnaissance level studies and report. During these studies, we evaluated building a concrete floodwall along the Chattooga River adjacent to the Regal Mill, building an earth levee and concrete floodwall adjacent to the school, and raising the height of the existing levee adjacent to Frogtown. These plans were evaluated individually and in combination for a total of eight plans. Our preliminary studies found the only feasible plan to be the floodwall adjacent to the Regal Mill. This plan would cost about $1,767,000 for detailed design and construction and has a benefit to cost ratio of 1.21. The town of Trion's share of this cost would be about $442,000. The other plans were estimated to range in cost from about $478,000 for raising the height of the existing levee at Frogtown to about $3,514,000 for building all three levees. We will send you copies of the completed reconnaissance report.

Before the Corps can recommend a plan for construction, however, a feasibility study would be required. The current estimated cost for completing the feasibility study is about $330,000, which would be cost shared on a 50-50 basis. Trion's estimated cash contribution for the study would be $156,000. This allows for $9,000 in contributed services. In the course of the feasibility study, we would reevaluate all the plans studied during the reconnaissance plus any additonal plans that can be developed. Topographic surveys of the study area would be made to aid in developing accurate cost estimates and in analyzing the project benefits. At the conclusion of the study we would recommend one plan for construction. This must be the plan that maximizes the net benefits and has a

benefit to cost ratio greater than 1.0. If, however, we do not identify an economically justifiable plan, then we would recommend termination of further federal involvement.

I hope this letter gives you a realistic idea of the study process that we must follow. Please furnish us a letter stating Trion's intent concerning the feasibility phase of studies. If the town of Trion would like to continue to the feasibility phase, then Mr. Bob Allen, Study Manager, could meet with you to answer any questions you may have. If you have any other questions concerning the contents of this letter or the feasibility study, please do not hesitate to call Bob Allen at (205) 694-3806.

Sincerely,

N. D. McClure IV
Chief, Planning and
Environmental Division

Georgia Department of Natural Resources

J. Leonard Ledbetter, Commissioner

205 Butler Street, S.E., Suite 1352, Atlanta, Georgia 30334
O.R. Cothran, III, Director, Parks, Recreation and Historic Sites Division
404/656-2770

March 12, 1991

Mr. Hugh A. McClellan, Chief
Environment & Resources Branch
Mobile District
Corps of Engineers
P. O. Box 2288
Mobile, Alabama 36628-0001

RE: Study of Chattooga River Levee,
Trion, Chattooga County, Georgia
HP901029-002 (Follow-Up)

Dear Mr. McClellan:

The Historic Preservation Section has reviewed the project description, map and photographs for the Chattooga River Levee Project, Trion. We understand this study consists of constructing a levee on both sides of the Chattooga River and increasing the height of the existing soil conservation service levee by about 4 feet.

We agree that per 36 CFR Part 800, this project undertaking will have no effect on the characteristics that qualify the mill buildings, adjacent mill village, the Park Avenue Bridge and the Norfolk Southern Railroad Bridge for listing in the National Register of Historic Places.

If we may be of further assistance, please contact Audrey Entorf, Environmental Review Coordinator at (404) 656-2840.

Sincerely,

Elizabeth A. Lyon
Elizabeth A. Lyon
State Historic Preservation Officer

EAL:aer:31

cc: Kitty Houston, Coosa Valley RDC

CESAM-PD-EI Mr. Jones/jdj/2725/14 Feb 91

MEMORANDUM THRU

PD-E
PD
PD-F

FOR PD-FP

SUBJECT: Environmental Information for Reconnaissance Report at Trion, Georgia, and PD-EI Cost for preparing Environmental Documents for the Detailed Project Report

1. Preliminary coordination with the Fish & Wildlife Service's (FWS) field office in Brunswick, Georgia, indicates that there will be no significant adverse impacts to fish or wildlife. A review of the plans by PD-EI also indicates that the proposed action will not adversely affect the environment and that an Environmental Assessment (EA) and 404(b)(1) will be required for this project.

2. A cost estimate for the preparation of the EA, 404(b),(1), and FWS coordination is also enclosed for your reference.

3. If you have any questions regarding this project please contact Jerry Jones at 2725.

Encl

GLENDON L. COFFEE
Chief, Inland Environment
Section

APPENDIX C

ECONOMIC ANALYSIS

ECONOMIC ANALYSIS

INTRODUCTION

The purpose of this analysis is to evaluate proposed flood damage reduction measures at Trion, Georgia. There are 4 sections to this report.

1. Socio-Demographic Profile
2. Physical Characteristics of the Study Area
3. Damage Computations for Without Project Condition
4. Determination of NED Benefits

SOCIO-DEMOGRAPHIC PROFILE

General. The Chattooga River originates in northwest Georgia and is a tributary of the Coosa River. The river flows southwesterly through the Town of Trion into Weiss Lake in northeast Alabama. The Town of Trion is located in Chattogga County, Georgia and forms part of the border with the State of Alabama. The town is approximately 30 miles northwest of Rome, Georgia and 70 miles south of Chattanooga, Tennessee.

Population. The U.S. Census of Population for Chattooga County totaled 21,856 persons in 1980. Trion had a total population of 1,732 in 1980. From 1970 to 1980, the county's population increased 3.0 percent. The 1980 county population measured 0.4 percent of the state's total population which numbered 5,463,105. Table 1 displays selected demographics for the State and County.

The Bureau of Economic Analysis, through county-level projections, estimates the population of Chattooga County to total 22,194 persons in 1990. The County is estimated to expand to a total population of 22,281 by the year 1993, the project completion date. The population of the State of Georgia is projected to number 6,323,488 persons in 1990 and 6,496,946 people in the year 1993.

Trion is estimated to contain 3 square miles of area. The racial composition of 1980 population of the Town is 98% white and 2% black. The median age of the town's residents in 1980 was 44. Approximately 60 percent of the population was between the age of 18 and 64. In comparison, Chattooga County in 1980 measured 17 square miles. The County's racial distribution in 1980 was 91% white and 9% black and the median age of a resident in the County was 32. Approximately 58 percent of the 1980 Chattooga County population was between the age of 18 and 64.

Employment and Earnings. County Level Projections of Economic Activity estimated total employment in Chattooga County to number 8,953 workers in 1990. Four thousand two hundred sixty-six workers were employed in manufacturing and seven hundred seventy-four jobs were held in nonmanufacturing. The State of Georgia contained 3,181,470 total job holders during the same period of time.

Between 1990 and 1993, employment is estimated to increase approximately 1 percent in Chattooga County as the State of Georgia is projected to average growth of 4 percent. Manufacturing employment in the state was 19 percent of Georgia's total employed in 1990 while Chattooga County's manufacturing workers was 48 percent of the county's total employment.

Total 1990 earnings in Chattooga County summed to $118,005,000. Earnings are from the Bureau of Economic Analysis (BEA) and are 1990 dollars updated by Consumer Prices (CPI-W) from the SURVEY OF CURRENT BUSINESS. Income in the state of Georgia was $57,504,450,300 in 1990. It is estimated that between 1990 and 1993 the county's wages will grow 5 percent while state salaries will increase 8 percent. The average wage, dividing total employment by total earnings, shows state-wide workers earning $18,075 in 1990 while county-wide workers averaged $13,180.

Table 1

Selected Demographics for the State of Georgia and the Town of Trion

Category		State of Georgia	Chattooga County	Town of Trion
1980 US Census: Georgia				
1980 Population		5,463,105	21,856	1,732
Percent White		73.2%	91.4%	97.8%
Percent Black		26.8%	8.6%	2.2%
Percent under 18 age		30.1%	29.3%	21.4%
Percent 18 - 64 age		60.4%	58.1%	60.3%
Percent 65+ age		9.5%	12.6%	18.3%
Median age		28.6	32.1	44.5
Total Households		1,871,652	7,733	694
BEA County Projections				
1990 Est Population		6,323,488	22,194	n/a
1993 Est Population		6,496,946	22,281	n/a
2035 Est Population		8,306,835	25,344	n/a
Total Est 1990 Empl		3,181,470	8,953	n/a
Manu Employment		602,507	4,266	n/a
Non-Manu Employment		2,578,963	4,687	n/a
Total Est 1993 Empl		3,305,539	9,036	n/a
Manu Employment		617,577	4,230	n/a
Non-Manu Employment		2,687,962	4,806	n/a
1990 Est Total Earnings	1/	$57,504,450.3	$118,005.0	n/a
Manu Employment		$13,046,199.4	$68,618.9	n/a
Non-Manu Employment		$44,458,250.9	$49,386.1	n/a
1993 Est Total Earnings	1/	$62,058,448.2	$124,060.8	n/a
Manu Employment		$14,067,120.5	$71,127.9	n/a
Non-Manu Employment		$47,991,327.7	$52,932.9	n/a

1/ Earnings are stated in thousands of dollars at a 1990 price level.

PHYSICAL CHARACTERISTICS OF THE STUDY AREA

General. The Town of Trion is divided by the Chattooga River. The floodplain primarily consists of residential development (91%). The majority of the residential structures are two story duplexes. The typical residential structure is built on piers and has a first floor elevation 2.0 feet above ground level. The residential properties are slightly under 2 percent of the total value of the floodplain with most of the worth of the floodplain in the industrial and public category.

Subdividing the Flood Plain. Three reaches were established in the floodplain to show spatial dispersion of the structures and points of significant change in either hydrologic or hydraulic characteristics of the floodplain. A map of the floodplain shows the location of the reaches on Figure 1.

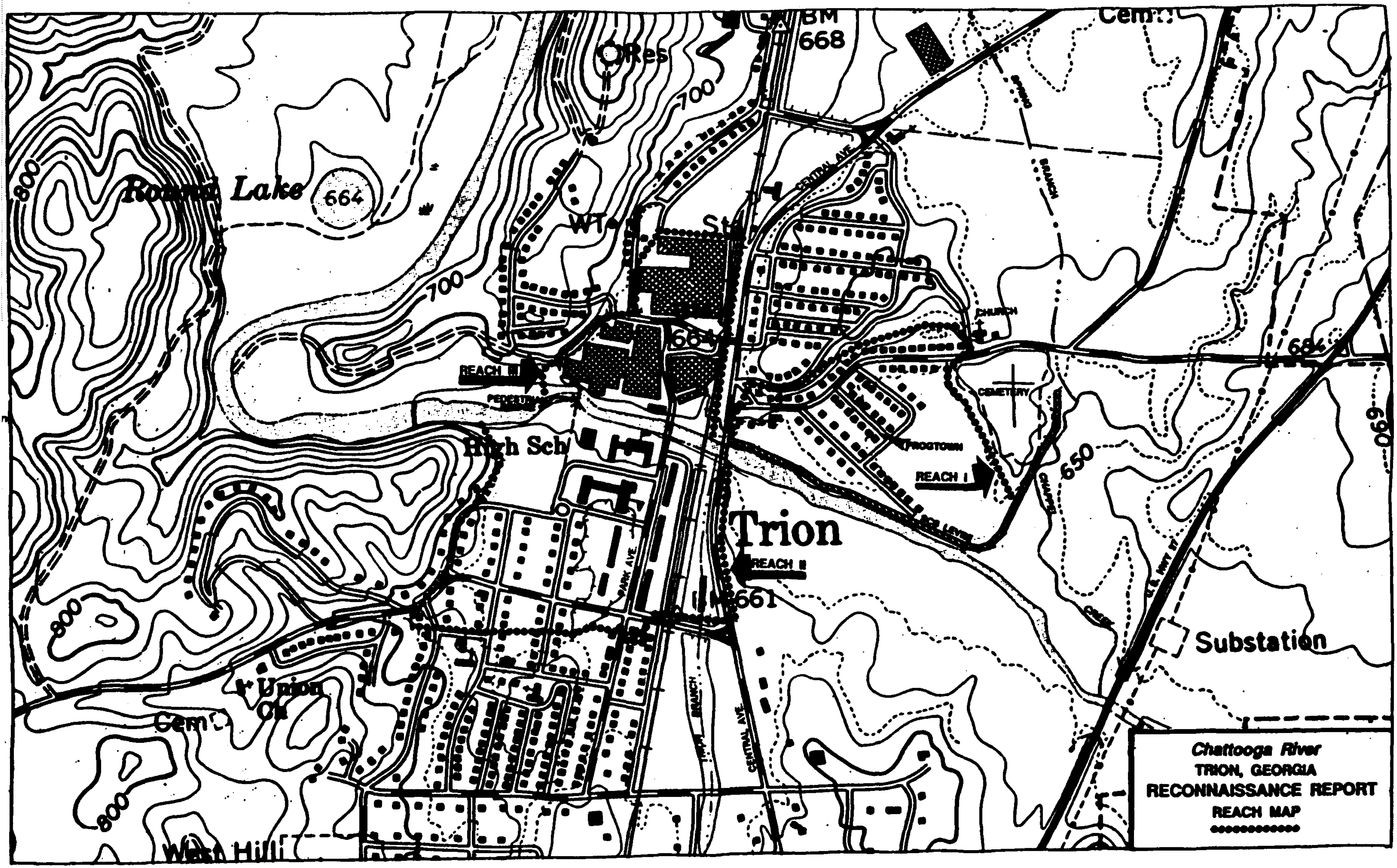
The Chattooga River divides the town into eastern and western sections. Reach 1 is the southeastern portion of the town and includes the residential area known as Frogtown. Reach 1 has an existing Soil Conservation System levee along the river. Reaches 2 and 3 are unprotected. The western side of the floodplain is identified in this report as reach 2 and includes a school. Reach 3 is the northeastern area of town and includes a textile mill.

Inventory of Property in the Flood Plain. During September 1990 a field trip to Trion, Georgia was made by SAM-PD-FE personnel. The floodplain was inventoried to determine: (1) the category and type of the structures, (2) the ground and first floor elevation of the buildings, and (3) the value of the buildings and their contents in the floodplain.

The category and building type of each structure was determined by a windshield survey. The ground elevation of each structure was estimated by surveying the elevation of the corners of the street blocks in the floodplain and interpolating the elevation change along each street. First floor elevations were estimated using professional judgement. Structural values were based on the county tax assessors records. Nonresidential building contents were estimated using historical data for comparable buildings from previous studies. Atypical businesses were surveyed to gather structure, inventory and equipment values.

The study area contained 169 structures valued at $235,264,600 in September 1990. One-hundred and fifty-four structures were residential, 5 were commercial and 10 were public or industrial. As a percentage of the value of the floodplain, approximately 1 percent is commercial, 2 percent is residential, and 97 percent is public or industrial. The inventory of the floodplain is aggregated to avoid disclosure of data on individual businesses. Table 2 displays the number of structures and their aggregated values by category.

FIGURE 1



Trion
REACH I
REACH II
REACH III
High Sch
Substation
Union Ch
Cem
West Hill
BM 668
Res
700
800
650
690
664
661
684
CENTRAL AVE
PARK AVE
CHURCH
CEMETERY
FROGTOWN
SPRING BRANCH
CHAPPEL CREEK
Chattooga River
TRION, GEORGIA
RECONNAISSANCE REPORT
REACH MAP

Table 2

Trion, Ga Inventory of Property

Category of Property	# Strs	$ Value
Residential	154	$3,651,700
Commercial	5	$1,786,500
Industrial + Public	10	$229,826,400
Transportation	0	$0
Utilities + Communications	0	$0
Public Health + Relief	0	$0
Total	169	$235,264,600

Dollar Damage by Flood Hazard. Spatial dispersion, when combined with first-floor elevation of each structure is used to predict the potential for flood losses in this floodplain. Table 3 presents this data in a damage-frequency table for the entire floodplain. As shown on Table 3, damages from a 500 year flood (.2% annual probability) would cause estimated damage of $136,696,700 to the study area.

Table 3

Trion, Ga: Damage versus Frequency

Exceedance Frequency	Existing Condition Damage
50.00	$0
20.00	$0
10.00	$525,700
4.00	$1,231,500
2.00	$1,697,100
1.00	$28,728,700
0.20	$136,696,700
Average Annual	$ 1,307,900

DAMAGE COMPUTATION FOR WITHOUT PROJECT CONDITIONS

This section presents the data, assumptions, constraints, and methodology utilized in the computation of average annual equivalent flood damages for the study area conditions which would exist without the implementation of a Federal flood control project.

Assumptions:

a. Residents will react to a floodplain management plan in an economically rational manner.

b. Real property will continue to be repaired to preflood conditions subsequent to each flood event.

c. The assumptions contained within the BEA population projections are considered appropriate for the purposes of this study.

d. The Federal Flood Insurance Administration's 1986 percent damage versus depth relationships for residential property were considered appropriate and accurate for the residential properties located in the floodplain.

e. Fair market value appraisals from the County tax assessor office of the structures and lands in the flood plain included the effects of all market conditions, including the effects of recognition of the flood hazard.

f. The properties in the floodplain are valued in September 1990 dollars.

g. The interest and amortization factor to compute the average annual cost for the with project measures is 8 3/4 percent.

Constraints:

a. The value of contents of single and multi-family residential structures is assumed to be 50% of the structure value, which is based upon insurance industry policy standards. This percentage is supported by the August 1990 report: POST FLOOD DAMAGE SURVEY AND ANALYSIS FOR ELBA, ALABAMA, LEVEE FAILURE, MARCH 1990 that was provided to the Mobile District by Gulf Engineers & Consultants.

b. The remaining physical life of all structures in the floodplain is 50 years.

c. No additional development is expected in the floodplain in the future.

The Calculation Process:

Quantification of flood damages is a process involving the integration of relevant data on floodplain development with hydraulic data on flooding. Flood damage is traditionally expressed in terms of a dollar amount of damage and incorporates three types of relationships: flood elevation versus frequency of occurrence (stage-frequency curves); depth of inundation versus percent of value damages for each type of floodplain development (depth-percent damage curves); and elevations of the various types of development versus the flood elevations for various flood frequencies indexed to their particular site (stage-damage curve).

The computation process can be divided into two major segments: the first segment results in the determination of an overall relationship between flood elevation in a particular reach and the total dollar amount of damage which results at any given flood elevation in the reach (damage to all the types of development summed as a single dollar amount). This segment estimates stage versus damage to 9 types of structures in the residential category and up to 217 types of nonresidential structures in the remaining categories. Stage-Damage to the subareas of roads + bridges, communications + utilities, and public safety were calculated as 2.0, 3.8, and 6.5 percent of the total estimated damage in the above 226 categories.

The second segment combines the stage-damage relationships in each reach with elevation-frequency, to produce a damage-frequency relationship. These two major computational segments, for purposes of this study, were accomplished by the Stage-Damage and Expected Annual Damage (EAD) computer programs.

Existing Condition Damages:

Table 3 displays the damages which would occur with any one of seven specified flood events. On an annual basis, however, these potential flood losses must be subjected to a probability analysis (frequency of events), which are called "average annual flood damages" under existing conditions. The total average annual damage under existing conditions in the Trion, Georgia floodplain is $1,319,000 and is shown on Table 4. Average annual damage is $43,700, $83,700, and $1,191,600 for reaches 1, 2, and 3 respectively.

Table 4
Trion, Georgia
Average Annual Damage

Category of Property	Total
Residential	$47,800
Commercial	$8,500
Industrial + Public	$1,118,200
Transportation	$23,500
Utilities + Communications	$44,600
Public Health + Relief	$76,300
Total	$1,319,000

Without Project Condition Damages. No real future growth is anticipated in this floodplain and the existing condition is considered to be the without project future condition. Using the previously described method, average annual flood damage was calculated for the Trion, Georgia study area with existing (September 1990) prices and development.

For the purposes of this study, the period of analysis is 50 years and the remaining useful life of all structures is estimated to be 50 years. Specifically, all structures will be assumed to be continually maintained or repaired to preflood conditions as circumstances dictate. According to current planning guidelines, the interest rate to be used for Fiscal Year 1990 is set at 8.750 percent.

DETERMINATION OF NED BENEFITS

With Project Condition. This analysis is to determine if a Reconnaissance alternative is found to be feasible to warrant further study in completing a project. This analysis considers various combinations of the replacement of one levee and the construction of two flood walls in the three reaches. No nonstructural alternatives were considered at this level of study.

One levee and two concrete flood walls were considered in the seven with plan conditions. The heights of the levees and flood walls in this appendix are equal to the physical top of the structures. This elevation includes 2 feet of freeboard. The damages and damages reduced were calculated using one half of the freeboard. The without project future condition levee, in reach 1, was constructed by the Soil Conservation Service. The present height of this levee is 659 feet. This levee is considered to protect to elevation 658 (657' + (.5 x 2')) which is approximately the 10 year event.

The with plan levee in reach 1 (Frogtown) is to be built to 662.75. This levee's level of protection (661.75) is approximately to the 75 year event (elevation (660.75 + (.5 x 2')). The flood walls in reaches 2 and 3 are to be built to a height of 665.0 feet. The level of protection [663 + (.5 x2)= 664] of the flood walls in reach 2 (School) and reach 3 (Mill) is approximately to the 200 year event.

Structural Plans. Seven alternatives are considered at Trion, Georgia. Plan 1 is a no action plan. Plan 2 is the construction of a flood wall to elevation 665.0 in the School/City Hall reach 2 only. Plan 3 is a buildup of an existing Soil Conservation levee located in the Frogtown area (reach 1) to elevation 662.75 only. Plan 4 is the construction of a flood wall to elevation 665.0 in reach 3, the Mill area only. Plan 5 is the combination of plans 2 and 3. Plan 6 is a combination plan of plans 2 and 4; and plan 7 is a combination of plans 2, 3, and 4. Lastly, plan 8 is like plan 3,(elevation 662.75) but this plan contains overbank clearing of 220 feet of the floodway on the opposite side (south) of the levee. Table 5 displays study area's average annual damage in Plan 1, and the average annual damage remaining of the 7 plans considered.

A single cross section was used to represent flooding in each of the 3 reaches. Cross section 139.70 corresponds to the reach that includes the area known as Frogtown (Reach 1). Excluding the without project condition, cross section 142.04 represents the reach which includes the school (Reach 2) and cross section 144.40 represents the Mill (Reach 3).

The without project condition used cross section 144.70 for the school and the same cross sections in the above paragraph (149.4 + 139.7) for the Mill and Frogtown reaches. The change from cross section 142.40 to 144.70 at reach 2 (the area that included the school) is based on the change where flooding occurs. Under the without project condition, flooding is considered to overtop the levee. The with plan condition (where a levee is in place in reach 2) assumes that flooding will occur from low ground upstream of the levee.

Table 5
Average Annual Damage Remaining
$1,000

Category	W/Out Proj Plan 1	Structural Alternatives Plan 2	Plan 3	Plan 4	Plan 5	Plan 6	Plan 7	Plan 8
Residential	$47.9	$46.2	$19.5	$44.3	$17.6	$42.7	$13.6	$17.1
Commercial	$8.5	$2.7	$8.6	$8.5	$2.8	$2.8	$2.8	$6.5
Ind. + Public	$1,118.2	$1,100.1	$1,197.3	$960.3	$1,145.2	$941.0	$940.4	$1,123.0
Transport	$23.5	$23.0	$24.5	$20.3	$23.3	$19.7	$19.1	$22.9
Util + Commun	$44.6	$43.7	$46.6	$38.5	$44.3	$37.5	$36.4	$43.6
Pub Health	$76.3	$74.7	$79.7	$65.8	$75.8	$64.1	$62.2	$74.5
Total	$1,319.0	$1,290.4	$1,376.2	$1,137.7	$1,309.0	$1,107.8	$1,074.5	$1,287.6

Plan Evaluation. In water resource planning, the Federal objective is to contribute to National Economic Development while protecting the nation's environment pursuant to applicable laws, regulations, policy and guidance.

Table 6 presents the benefits attributable to each structural plan using September 1990 price levels and discount rates. The without project condition damages are $1,319,000. See the Plan Formulation Appendix for a summary of the average annual costs of each plan.

Table 6
Average Annual Damage Reduced
$1,000

Category	Structural Alternatives						
	Plan 2	Plan 3	Plan 4	Plan 5	Plan 6	Plan 7	Plan 8
Residential	$1.7	$28.4	$3.6	$30.3	$5.2	$34.3	$30.8
Commercial	$5.8	($0.1)	$0.0	$5.7	$5.7	$5.7	$2.0
Ind. + Public	$18.1	($79.1)	$157.9	($27.0)	$177.2	$177.8	($4.8)
Transport	$0.5	($1.0)	$3.2	$0.2	$3.8	$4.4	$0.6
Util + Commun	$0.9	($2.0)	$6.1	$0.3	$7.1	$8.2	$1.0
Pub Health	$1.6	($3.4)	$10.5	$0.5	$12.2	$14.1	$1.8
Total	$28.6	($57.2)	$181.3	$10.0	$211.2	$244.5	$31.4

Plan 4 was the only plan to have a benefit to cost ratio greater than unity. Table 7 shows the damages reduced (benefits) to each plan, the cost of each plan, and net benefits. The NED (National Economic Development) is this plan.

The incremental benefits and costs of the NED plan were reviewed to insure that each reach was incrementally justified. By reach, the benefits attributable to the NED plan are: $ 0.0 for Reach 1, $ -0.8 for Reach 2, and $ 182.1 for Reach 3. The costs, by reach, of the NED plan were $ 0.0, $ 0.0, and $ 150.1.

Table 7
Plan Benefits and Costs
$ 1,000

Plan Number	Avg Ann Benefits	Avg Ann Costs	Net Benefits	B/C Ratio
2	$28.6	$110.7	($82.1)	0.26
3	($57.2)	$27.8	($85.0)	-2.06
4	$181.3	$150.1	$31.2	1.21
5	$10.0	$144.9	($134.9)	0.07
6	$211.2	$260.7	($49.5)	0.81
7	$244.5	$295.0	($50.5)	0.83
8	$31.4	$29.9	($1.5)	1.05

APPENDIX D

ENGINERRING

Section 205 Reconnaissance Report
Trion Georgia
Hydrology Section

Introduction

Trion is located in Northwest Georgia in Chattooga County. The Chattooga River flows in an easterly direction through Trion and has a drainage area of 156 square miles at Central Avenue.

Gage Record

There is no streamgage at Trion, but gage data are available at Summerville, Georgia which is downstream of Trion on the Chattooga River. The drainage area of the Summerville gage is 193 square miles. This gage has been in place since 1938 and has 53 years of good data. The flood of February 1990 was the largest flood to occur during the period of record. The peak discharge was 31,000 cubic feet per second (cfs) which was estimated to be a 70 year event. Other large floods occurred in March 1951 (24,500 cfs), 1949 (22,700 cfs) and 1966 (20,400 cfs).

Discharge Frequency Estimate

The February 1990 discharge estimate was included in the Summerville gage record and frequency statistics were computed. These statistics were then used with the regional equations to estimate the discharge-frequency curve at Trion. Table 1 lists the peak discharges for selected frequencies at Central Avenue.

Table 1
Summary of Discharges
Chattooga River at Central Avenue

10 Year	15,000 cfs
50 Year	23,000 cfs
100 Year	26,800 cfs
500 Year	36,500 cfs

Interior Runoff

To protect the area upstream of Central Avenue and south of the Chattooga River from flooding from the river a levee and floodwall was proposed. This levee will prevent the runoff from the protected area from reaching the river and a culvert or pumping station is needed to remove this accumulation of water. Runoff from the area behind the levee was computed by the using the SCS unit hydrograph and curve number method. The drainage area of the basin behind the levee was delininated on the USGS 7 $^1/_2$" quadrangle sheet for Trion, Ga. and was determined to be .37 square miles. The average basin slope was also determined from this map. The lag time for the area was computed by the equation;

$$L= l^{.8}*(S+1)^{.7} / 1900*(Y)^{.5}$$

where:

L= basin time lag in hours= .72

l= basin length in feet= 7390

S= $^{1000}/_{CN}$ - 10= 3.33

CN= SCS loss rate curve number= 75

Y= basin slope in %= 6.4

The 100 year rainfall was determined from the National Weather Service Technical Paper 40 (TP 40). The runoff program HEC-1 was used with the unit hydrograph parameters and rainfall to compute the 100 flood hydrograph from the area behind the levee. The peak discharge was computed to be 350 cfs and the ruoff volume was found to be 37 acre feet.

HYDRAULICS APPENDIX

CHATTOOGA RIVER

TRION, GA

The city of Trion had a flood insurance study completed in 1979. The HEC-2 model for that study was obtained and modified for use in this report. In 1980, the Soil Conservation Service constructed a levee along a portion of the left bank below Central Avenue. This levee was added to the FEMA model to provide the existing conditions model for this study. Existing condition stages for two cross sections are shown in Table 1. The first floor elevation of the elementary school is 658.9 and the high water mark for the March flood was 662.4 adjacent to the school.

The alternatives modeled in this study included raising the SCS levee, building a levee adjacent to the school and building a floodwall adjacent to the mill. These alternatives were run individually and then several combinations of the three to determine flood elevations for a total of eight plans. Plan 4, protection of the mill, was the only alternative which had a favorable benefit-cost ratio.

TABLE 1

FREQUENCY (YEARS)	STAGE (FEET)	
	SECTION * 144.70	SECTION # 139.70
2	654.03	653.85
5	656.18	655.98
10	658.27	658.02
25	660.61	659.89
50	662.54	661.14
100	663.89	662.41
500	667.00	665.94
SPF	668.51	667.97

* Section 144.70 is on the upstream side of Park Avenue
\# Section 139.70 is on the downstream side of Central Avenue

GENERAL DESIGN MEMORANDUM

PASCAGOULA HARBOR
CHANNEL IMPROVEMENT

PASCAGOULA, MISSISSIPPI

MAIN REPORT

PASCAGOULA HARBOR, MISSISSIPPI
GENERAL DESIGN MEMORANDUM

MAIN REPORT
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PERTINENT DATA TABLE

NAVIGATION CHANNEL DREDGING

Reach	Channel Dimensions ft	Dredging Quantities 1000 cy
Upper Pascagoula	39X300	1,856
Bayou Casotte	42x300	6,419
Lower Pascagoula	42x350	2,079
Transition	42x350 to 44x600	1,370
Horn Island Pass	44x600	756
Transition	44X600 to 44X450	1,133
Gulf Approach	44x450	2,910

PHASE I CONSTRUCTION
(same improved dimensions at existing depth)

Bayou Casotte Turning Basin	Turning Diameter - 1150	2,489
Horn Island Pass (with transitions)	44X600	2,007
Gulf Approach	44X450	4,489